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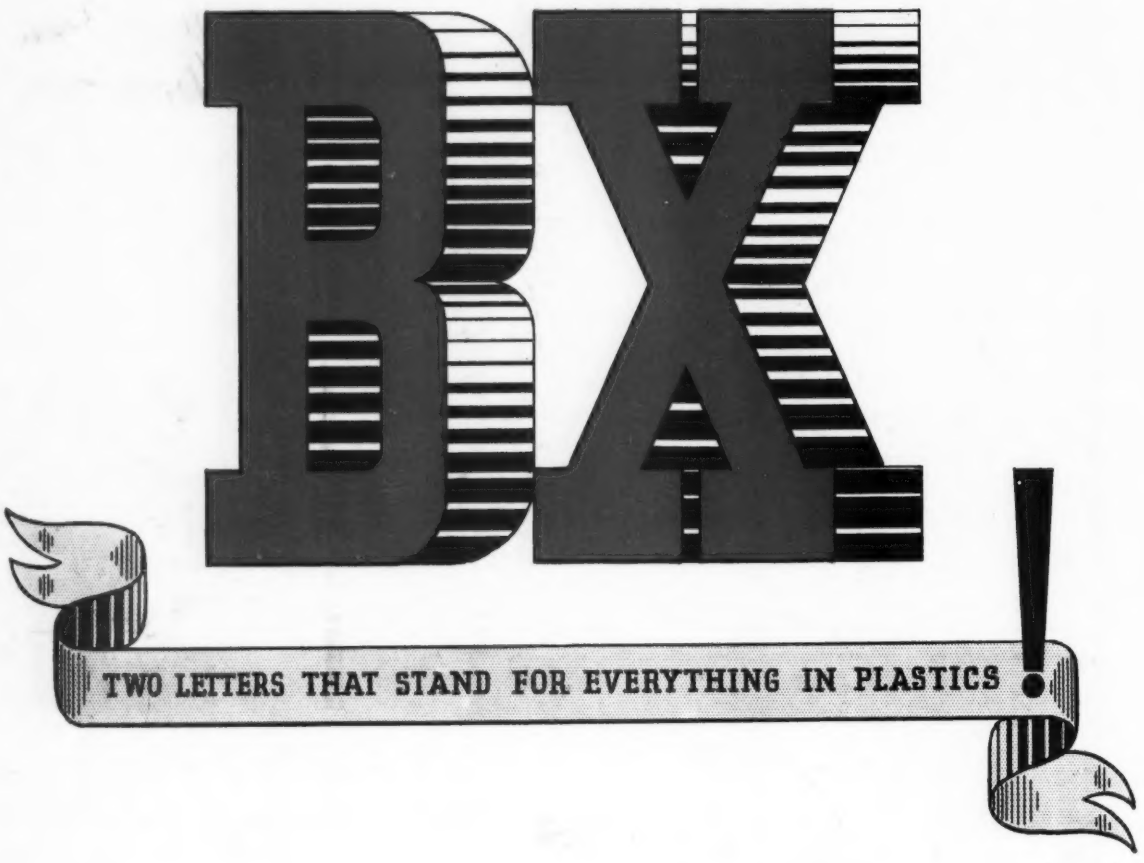
Plastics

DEALING WITH THE MANUFACTURE USES AND POTENTIALITIES OF PLASTIC MATERIALS



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Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Vol. IV DECEMBER, 1940 No. 43

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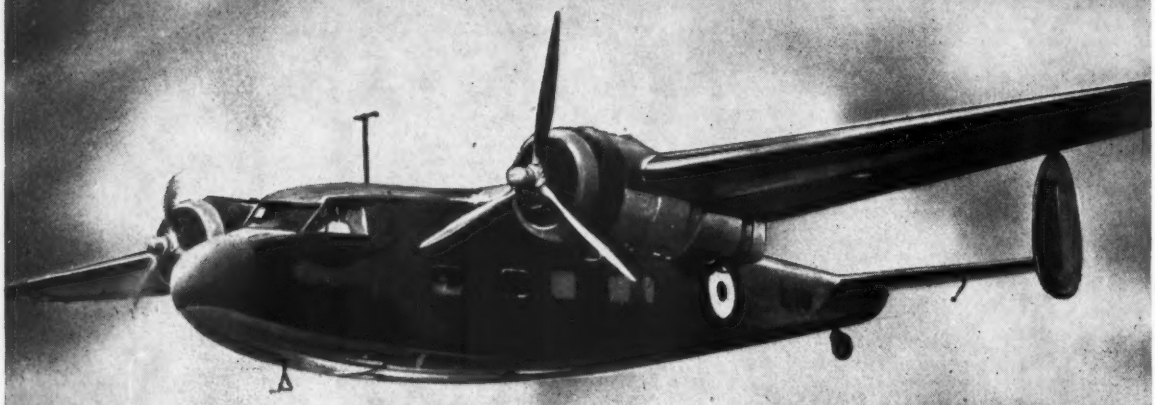
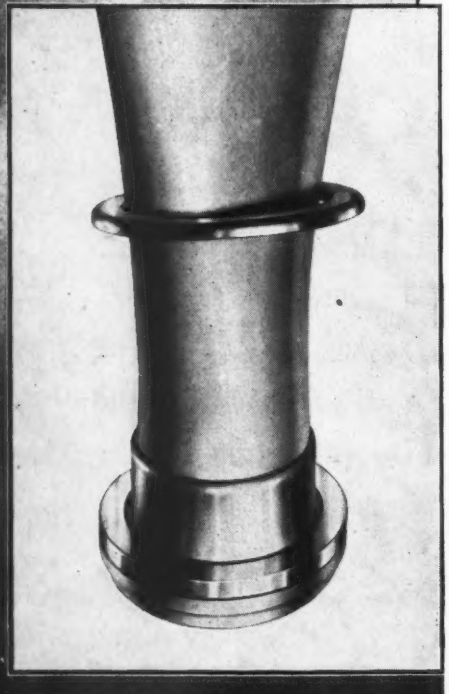
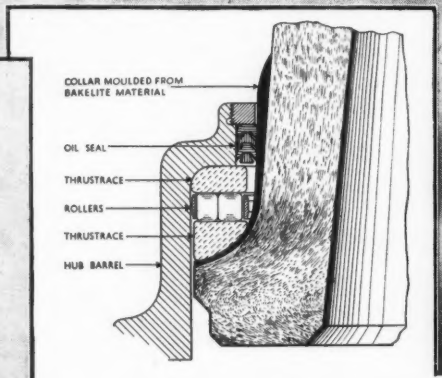
BAKELITE *Materials*

CONTRIBUTE TO THE SUCCESS OF THE DE HAVILLAND HYDROMATIC AIRSCREW







The De Havilland hydromatic airscrew incorporates a collar moulded around the blade shank under the thrust race. This collar, which is moulded from BAKELITE Materials, acts as a vibration insulator. It also eliminates all possibility of the thrust race galling the blade shank. For these reasons relatively small blade shanks can be used with safety. This collar also allows the use of an oil seal, without the risk of scoring the blade and so setting up stress concentrations.

This is but one example of the many uses of BAKELITE Materials in aircraft manufacture.

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THE MATERIAL OF INFINITE USES

Vol. IV. No. 43 DECEMBER, 1940

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Proprietors - TEMPLE PRESS LIMITED
Managing Director - ROLAND E. DANGERFIELD

Editor - - M. D. CURWEN, B.Sc., A.I.C.
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Spongy Plastics

IN our November issue we mentioned that we hoped one day to see a cellular type of plastic similar to expanded rubber, for example, cellulose acetate or other thermo-plastic, which might prove more suitable than the non-cellular variety for refrigeration purposes. It is with considerable pleasure that we note a recent patent dealing with spongy or cellular materials derived from polythene, the remarkable plastic made by polymerizing ethylene and which can be made as an elastic material or as a very tough horn-like substance. It is extensively used for electrical work, especially in the extruded form as tube or tape.

The polythene is melted in the presence of a gas under pressure or the gas may be introduced under pressure into the molten material and the pressure subsequently reduced. The frothy melt is allowed to cool and solidify. A wide range of specific gravities for this material can obviously be produced; they are stated to vary as required between 0.01 and 0.5.

As we have not yet seen a sample of this substance we cannot say how closely it approaches the type of material we discussed. What we are looking for is a sheet or block which would contain these cells and yet possess sufficient tensile strength to be shaped and cut or even moulded into a door for refrigerators, or, alternatively, a sheet that could be wrapped and " welded " round a pipe without the necessity of a wire netting to hold it in position.

It may be that the polythene sponge is the answer, especially if it can be produced from both the elastic or the tough, horny variety at will.

On going to press we learn that one of the purposes of the process is to produce a material which could be used instead of cork in the event of present supplies from Spain being cut off.

Nylon Sandwich

WE seem to be harping somewhat continually on the subject of the new wonderful discovery and manufacture that is called nylon; but it is always fascinating and sometimes amusing to consider the variants and some of the economic changes that appear to accompany great discoveries.

It has been told that the research chemists of Du Pont de Nemours laboratories worked for some years to produce the material nylon which has aroused the enthusiasm of the scientists on five continents and has appeared on the market as a new fibre for use as bristles, the making of stockings, etc. In this country two large factories are being erected for the manufacture of nylon.

Here, then, is a very good example of how all scientifically advanced countries are making themselves "totalitarian," a condition which has little to do with dictatorships. And, if we remember aright, Great Britain was the very first to begin the game, for it was Sir William Perkin who discovered the first synthetic dyestuff and so set the pace to oust natural colours and to promote home manufacture. Our great democracy also saw the first factory to make synthetic rubber, although it was not a very long-lived one, and Cross and Bevan, two Englishmen, made the very successful viscose artificial silk.

What will be the effect of nylon on the economic situation? What effect did the first synthetic dyestuff or artificial silk have? How will synthetic rubber change things, if at all? The first synthetic dyestuff, Mauvein, did not have much effect for, although it made one Englishman rich, it was used only in comparatively small quantities. A synthetic dyestuff which did upset the applecart, however, was synthetic indigo, a colour that was first made in Germany about the 1890's. Within a decade or two it had thrown tens of thousands of labourers in India out of work on the indigo tree plantations. On the other hand, the synthetic material was a much purer material and gave employment to many Germans and later Englishmen, Frenchmen, Americans, and so on when the process was employed elsewhere. This may be regarded as a classical example of the power for good or ill, depending on which way you regard it, of scientific research.

Artificial silk or rayon, as it is now generally called, is still too new for its effect to be examined and we do not know whether there are any published figures of the diminution in manufacture of real silk in Japan, China and Italy, but without doubt artificial silk has ousted the real variety to a great extent. If this is true with regard to both viscose and acetate "silk," both of which are inferior in "quality" with real silk, what is going to happen when nylon, which is stated to be "even better," is manufactured on a really big scale in America, Great Britain, France, Germany and any other technically important country that feels disposed to make it? Obviously the silk trades in Japan and China

will be hit as they have never before been hit, and while at the moment we are not exactly enamoured of Japan and her antics, there will be a pretty problem for the statesmen of the world to examine after the war, for millions of workers in Japan and China exist on the cultivation of the silkworm and the production of the fabric. The West-European nations and America, in which we include Canada, will all be self-sufficient in very remarkable fibres. To give a good example, the United States now takes nearly 78 per cent. of Japan's output, but by 1942 will be making over 7,000 tons of nylon fibre per annum equivalent to one-third of her Japanese silk imports. By then the British nylon factories will be in production and after the war others will follow suit. We have here a potent argument for Japan remaining friends with the U.S.A. and Great Britain and for the organization of a world-wide economic co-operation.

Which reminds us. Carothers and his remarkable team of co-workers in Du Pont's have produced the first synthetic protein. True, it is not in texture very much like the proteins we encounter in life, except the skins and horn-like proteins, although it does resemble them all chemically. How much more would we thank Dr. Carothers if he had devoted those years to producing a protein that would be more digestible than his nylon, which is so tough and not readily attacked by the gastric juices. Think of having a dozen chemical factories here turning out tens of thousands of tons of juicy nylon, already treated with dozens of vitamins and doses of the appropriate salts, extruded into just the right size for making sandwiches. And, of course, these factories would turn out not only beef flavour but ham, lamb and egg flavours, too! Think of the shipping we would save and how we could laugh at Hitler. This would be totalitarianism with a vengeance.

Scientists as Rulers

THE status of scientists and of science in the present world has in the past few weeks been the subject of talks by several distinguished people. Sir William Bragg, in his address before the Royal Society, insisted that Governments should be guided by scientists and their knowledge and hinted that scientists might even be more than mere consultants. Julian Huxley, in a broadcast, gave an admirable view of the value of research and of its perversion to dangerous and evil uses, and Air Marshal Sir Philip Joubert de la Ferté similarly decried the abased use of aircraft for war purposes.

The cry against scientists is as old as science itself, but grew to important dimensions during and after the last war as a result, perhaps, of the use of poison gas and other weapons, and one distinguished bishop even hoped for a 10-year stoppage of scientific endeavour and discovery. What this was to accomplish is not quite clear, but it showed the complete lack of thought in apportioning the blame. One might as well lay the blame of poison gas on Charles Tennant, who, somewhere about the time of the French Revolution, made chlorine gas for peaceful bleaching purposes and thereby laid the foundations for a part of the riches of this country, or blame the inventor of the internal-combustion engine for the use of tanks and bomber aircraft. It is the rulers or the people that are at fault in not being able to visualize or control the evil use of inventions and discoveries. Once war is declared, however, there is considerable truth in the statement that scientists help in promoting destruction, for their work on combating the evils is no greater than their efforts in discovering new ones. They are combined for patriotic motives in their researches, and, it may be added, work with fervour if not gusto. It must not be forgotten that they are as human as the man in the street.

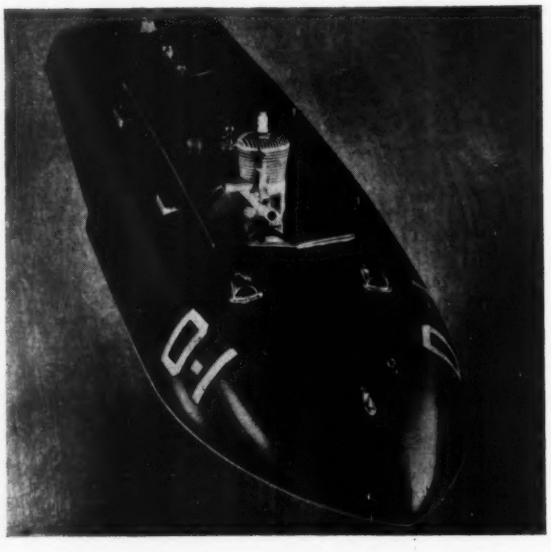
As to whether the scientist can act as ruler and could lay his finger on a particular purely scientific discovery at its inception and say "This one day will prove dangerous to humanity" is extremely doubtful. Few men, least of all the pure scientist who is usually out of touch with applied industrial science, are as far-sighted as this.

It seems to us that there would be no necessity to consider whether scientists could control the children of his brain if the economics of the world were better organized. This necessity has been hinted at by our Prime Minister and many others in the Government. We must, by some means, first control the economic wars that take place in peace-time.

This brings us back to our little dissertation in the preceding article. Most inventions and discoveries, whether synthetic dyestuffs, the spinning jenny, the steam engine, or nylon, have brought and will bring suffering through unemployment to some and happiness and employment to others. One great industrialist admitted this obvious truth, but declared that after a lag more universal employment was the final result. This was looked upon as a far-sighted way of regarding things, but he did not say what happens during the lag. Moreover, he was talking parochially, that is happenings within a country. What are we to do when the livelihood of the greater part of one nation is taken away by the modern scientific discoveries of another. It is a pity that the wonders of science cannot benefit us all at the same time, especially when these wonders are even improvements on natural materials.

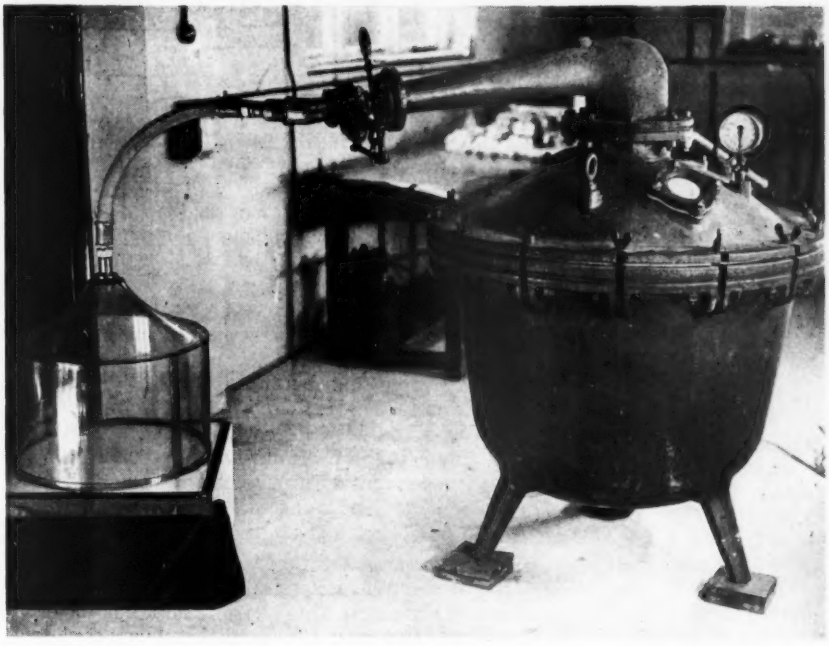
Motor-driven Hydroplane

It is pleasant to turn from the more portentous problems of life to the games of children—young and the not so young. Here is a photograph of a motor-driven hydroplane provided with a moulded plastic hull nearly 3 ft. long. The hull was designed by Reuhl Products, Inc., of U.S.A., and was moulded by Plastics Engineering Co. from Bakelite phenolic moulding powder.



THERMO-PLASTICS UNDER VACUUM

The Story of an Experiment that may have Important Repercussions in Scientific Research



The testing of shatter-proof glass under strain. The apparatus includes, left to right, Celastoid bell for observation purposes, gate valve and reserve vacuum chamber.

WE have often shown examples of the value of the transparency of the sheet thermo-plastics, cellulose acetate and acrylic resins in a variety of applications, e.g., for exhibiting the interior working parts of water heaters and motorcars, etc. Their success to the ever-wondering public eye was immediate, for we are all incurably inquisitive of what lies within, especially in machinery which is normally hidden from view. How much advantage will be taken of transparency in other and more industrial or scientific spheres is a matter of conjecture and one dependent largely on the strength of plastics. It is certain that many scientists, chemists and physicists would like to view the course of reactions that take place behind metallic containers. Obviously, most chemical reactions are for ever excluded from taking place in any plastic material, but the following notes show one physical experiment of an important nature that is now being carried out with success using transparent acetate sheet for its examination.

The accompanying photograph represents an arrangement used by Herts Pharmaceuticals, Ltd., of Bessemer Road, Welwyn Garden City, for testing various methods of making glass panes shatterproof by covering them with transparent adhesive tapes, viscose films and lacquers, rubber films, textile netting, and so on.

The chief part of the apparatus is the Celastoid cellulose acetate vacuum chamber shown on the left side of the picture. This is connected through a gate valve to a large reserve vacuum chamber, which is, in turn, connected to a vacuum pump.

The glass under test which has been treated with an anti-shatter material is placed so as to form the base of the vacuum chamber. With the gate valve closed, the air is pumped out of the reserve chamber until a vacuum of 20-in. mercury is formed. The gate valve is then rapidly opened, with the result that a sudden negative pressure is produced inside the Celastoid chamber and the glass under test breaks under the sudden strain to which it is subjected.

The shattering of the glass takes place so rapidly that the movement could not be followed by eye. To overcome this, a superspeed ciné camera is used to record the action at the rate of 2,000 exposures per second. The film permits observation on the screen of the breakage and splintering of the glass by reducing the speed.

For the purpose of filming, excellent transparency of the chamber is the chief requirement, and the clear cellulose acetate sheeting material adequately serves the purpose. The second requirement, of course, is strength. In the first tests a glass bell jar of 15 ins. diameter was used, but it was unable to stand the strain to which it was subjected. The cellulose chamber has a diameter of 22 ins. and, being 5 mm. thick, it easily withstands a vacuum of 20-in. mercury, which produces a total load on the glass pane of 3,600 lb. With this loading the whole of the tests were conducted without any visible distortion of the chamber, which, in fact, would remain perfectly rigid even when almost completely evacuated.

This chamber was produced by Thermo-Plastic Products, Ltd., of Dunstable. It is made entirely from Celastoid sheet in two parts, the pagoda-shaped roof being cemented to the circular wall and the lower circular edge having a rebate for taking a ¼-in.-diameter rubber ring which holds the vacuum.

ADHESIVES AND CEMENTS

A Comprehensive Discussion on Modern Adhesives and Cements Based on Synthetic Plastics, in which a Wide Range of Practical Formulae are Given

By E. E. HALLS

"STICKANTS," under various descriptions of glues, cements, adhesives, sealers, etc., enter into the activities of practically every industry, business and domestic field. Suitable materials for the numerous needs rapidly became recognized even in pre-civilized eras, and these have been added to from time to time. Mostly products from natural sources have been used such as the glues derived from bones and skins of animals and fish, starches and dextrines, plasters, drying oils of vegetable origin, resins and bitumens. While the serviceability of products having one or other of these materials as the adhesive base cannot be disputed, there is always the impetus for development and the exploration of new fields. Moreover, advances in civilization bring with them new problems and more arduous conditions to be satisfied. Again, the use of natural products often involves difficulties due to fluctuations in supply or variations in characteristics with season, complexities in defining quality and some troubles in ensuring by pertinent testing uniform of supply from batch to batch.

The employment of the new plastics as the base of "sticking" materials is, therefore, logical from several points of view. The most fundamental factor, however, is the versatility of synthetic plastics. A wide range of independent types is available; most of the types respond to modifying or compounding to minimize the undesirable features and to augment the properties apt to specific applications; availability in liquid or powder form or in solvent solution; these basic attributes give the possibility of providing air-drying or baking stickants, hard or soft, rigid or flexible, for the securing of numerous basic materials to themselves or to others. But another attractive feature of synthetic plastic adhesives is that they have as their binder-base a material manufactured under conditions of close control so that, chemically, it is a known and well-defined compound. Moreover, the ultimate sticking medium is produced to a proved formula and under rigid process control so that its behaviour is always the same. This consistency can generally be checked by simple inspection test methods of a chemical or physical nature, e.g., proximate composition, viscosity, specific gravity, drying time, etc. At the same time, it most definitely cannot be claimed that all of the established cements and adhesives can be replaced satisfactorily in all respects by synthetics. Rather is the position one in which the newer media supplement the older members in a wide field: in some applications they stand unrivalled, in others they achieve equal or better results more expeditiously or economically and, again, in some they cannot compete in initial cost, application rates or process convenience. In the following, it is proposed to deal with outstanding cements and adhesives from the different plastic bases, including proprietary and readily prepared products.

Criteria for the ideal stickant can only be given in general terms, but these may be concisely listed as under:—

1. Ease of application.
2. Rapidity of application.
3. Rapid drying or setting.
4. Adhesiveness towards both material surfaces.
5. Strength of junction.
6. Permanence of junction under service conditions which may impose fluctuating conditions, including those of mechanical stress (tension, vibration, flexing, etc.) or of atmosphere (hot and cold, wet and dry) as well as specific rigours such as oil or petrol immersion, chemical solutions, etc.
7. Regular availability in uniform quality.
8. Stability of the medium under normal storage conditions.
9. Freedom from harmful or unsightly corrosive action on materials secured together or upon those with which accidental contact is made.
10. Freedom from health hazards, that is, harmless to operators during use and in some instances devoid of poisonous ingredients.
11. Initial cost and ultimate cost.

Ideals are rarely reached in practice, but it is important to keep the criteria well in mind in order that they may be approached. The specific needs for each case must be considered, the essentials fulfilled as closely as practicable, with perhaps some compromise with respect to those criteria that are less critical in relation to that particular case. The criteria for the cements and adhesives are briefly reviewed below.

Industrial Necessities

The sticking medium needs to be easily applied, either by one of the standard methods or by an easily devised method. The established modes are brush, dip, spray, roller, spatula or palette knife. Specially devised methods include pressure gun, tube or reservoir. When mass production is involved, the medium applied by the selected method must be rapid in application with the minimum of loss and messiness. In brief, application should be straightforward and complications such as pressings and bakings should be brief and simple. These points do not necessarily carry the same weight when small quantities or single units only are entailed. The total time for air drying or setting, maturing or ageing is a factor falling in the same category—rapidly vital for large-scale work, but of less consequence on a smaller basis.

Adhesiveness is a function of the stickant and of the base material or materials, with the latter, of course, the determining factor. The same type of adhesive with appropriate modification may suit many different materials. Degree of polish or of matness, and regular or irregular roughness of surface; metal or non-metal, high or low-thermal expansion; absorbency, porosity, ease of wetting; all these are factors for consideration in deciding the adhesive. The strength of the junction will depend upon the adhesiveness of the joining material, with due attention to the points just mentioned, the workmanship and technique adopted to effect the join, and the service conditions imposed. The degree of per-

manence of the junction in service is dependent primarily upon an accurate forecast of service conditions and an appreciation of their significance. When this desirable set of circumstances exists, either a permanent junction can be achieved or the best available one devised with, moreover, a reasonable estimate of service durability.

Regular availability in uniform quality cannot be over-stressed because nothing is more annoying to production executives than to start manufacture on a preplanned basis only to find that a proprietary adhesive is no longer obtainable or that the laboratory have designed an excellent adhesive based upon ingredients difficult to obtain. Storage stability falls in a similar category. Storage life, and suitable conditions for best life must be known from the outset. A material that is affected by dampness or which suffers from drying-out can appropriately be catered for by correct storage conditions and quantity maintained. A laboratory product that is stable can be prepared in bulk, one that undergoes adverse changes can be compounded at frequent intervals, daily or weekly as the case may be.

Dangers of Corrosion and Safety Factors

In general, one would expect an essential would be freedom from chemical action between adhesive and base material since this is liable to be progressive and, in consequence weakening to the junction. While true in the main, this axiom does not always hold good. To quote one example, casein cements are strongly alkaline surfaces, and also exert quite a pronounced etching influence upon steels. Yet they can be employed satisfactorily against these materials, and this chemical action at the junction in part contributes to their success. On the other hand, an acidic resinous solution that readily greens brass cannot be accepted as the customer immediately predicts verdigris corrosion.

There must be no doubt concerning safety to operators during application. Undesirable ingredients should be avoided wherever possible, and due safeguards taken when this is not practicable. Toxic fumes from solvents should be properly exhausted, even when they are not injurious but only transiently objectionable. Thus chlorinated hydrocarbons (carbon tetrachloride, trichlorethylene, etc.) should be completely removed and solvent vapours from nitrocellulose products exhausted. Lead compounds as fillers are best avoided. Fire risk should be guarded against, since with each type of adhesive employed the dangers associated with it will be accurately known.

Finally, in assessing cost, it must always be remembered that intial cost of the medium rarely gives a true visualization of the cost of the job. Admittedly, it must be borne in mind, and it should not be out of proportion to the formulation involved. But the manner in which the stickant responds to the manufacturing methods is the first important feature, and the resulting influence upon cost is in nearly all cases the main expense of the job. Execution of the work in a sound fashion and serviceability of the product are the other important and vitally determining factors. An inexpensive adhesive, an awkward process, and an indifferent result are poor economies. An adhesive reasonably priced in relation to its component ingredients and the processes involved in its preparation; a convenient process; a neat, sound job having reliable durability: these commonsense factors are the elements of successful production.

Probably all the synthetic plastics are used in one outstanding cementing job or another, and many of them form the basis of established and useful cements or adhesives. For the present purpose, they will be dealt with for convenience under the following headings:

1. The resins of the phenol formaldehyde class.
2. The amino resins of the urea or thio urea variety.
3. Nitro-cellulose products.
4. Cellulose acetate products.
5. Polyvinyl adhesives.
6. Polystyrol adhesives.
7. Glyptal varnishes as sealing agents.
8. Chlorinated rubber products.
9. Casein cements and adhesives.

1. Products of the Phenol-formaldehyde Resin Class

Much versatility is offered within this group by virtue of the resin itself, whether liquid, solid or in solvent solution, whether modified by additions of rubber or of mineral loading matter, whether used as a "moulding powder" or through the medium of impregnated paper. The resin is produced by the condensation of phenol and formaldehyde in the presence of a catalyst. The resultant product is thermosetting, that is, under the influence of heat, or of a combination of pressure and heat, it becomes infusible and insoluble. It can exist in the uncured form in a liquid or solid state. These uncured forms are soluble in certain solvents, notably industrial methylated spirit in all proportions. In this way adhesive solutions designated cements and varnishes are evolved. The phenolic resins, in contrast with all natural resins and gums are not acidic in character, neither in their solid or liquid state, nor in solvent solution. They are neutral, chemically inert bodies, and the possibility of corrosive action upon metals does not arise. Small amounts of ammoniacal condensing agents may, however, be present, but these do not cause trouble. The final baked resin, properly applied, is hard, non-flexible and adherent. It withstands heat, although not high temperatures for indefinite times. It is susceptible to blistering about 135 degrees C., but will withstand temperatures up to 100 degrees C. almost indefinitely. Electrically, it exhibits high electric strength and insulation resistance, but under certain circumstances may fail by tracking, that is, formation of conducting carbon paths, this usually occurring between closely positioned conductors under damp conditions. The shortcoming of the phenolic resin can be offset or minimized by appropriate compounding. The incorporation of mineral loading material, e.g., diatomaceous earth, plaster of paris, china clay, etc., helps in several directions. It reduces shrinkage, renders curing more easy and rapid without blistering; it reduces the tendency to electrically track. It makes the mass less fluid during baking, so that larger clearances between the mating components can be dealt with successfully. Air-drying flexible adhesives can be procured by compounding with rubber solutions. Air-drying or baking adhesives of a flexible nature are obtained by using oil soluble phenolic resins in a china wood oil vehicle with American turpentine or turps substitute as solvent. Adhesive properties can be modified by appropriate additions of shellac solutions to phenolic resin varnishes.

Typical Examples of Phenolic Fixatives

Tables Nos. 1 to 4 depict typical phenolic resin fixative materials. Table No. 1 deals with the straightforward cement and varnish products. The materials

Table No. 1.—Characteristics of Phenol-formaldehyde Cement and Varnish.

Sample No.	1	2
Source	A	A
Description	Cement	Varnish
Chemical:		
Volatile Spirit (loss, 3 hours at 110°C.) %	14.2	42.0
Total Solids (phenol-formaldehyde resin) %	85.8	58.0
	100.0	100.0
Reaction	Alkaline	Slightly Alkaline
Physical:		
Viscosity at 25°C., centipoises	4,500	280
Specific Gravity at 25°C.	1.215	1.035

Table No. 1A.—Characteristics of Phenolic Resin Oil Varnishes Suitable for Air Drying or Stoving.

Sample No.	2A	2B	2C
Source	American	American	British
Compositional, %:			
Volatile Spirit (loss, 3 hours at 110°C.)	39.5	35.0	40.0
Total film forming solids	60.5	65.0	60.0
	100.0	100.0	100.0
Physical:			
Viscosity at 25°C., centipoises	450	760	600
Specific Gravity at 25°C.	1.034	0.033	1.025
Drying time:			
Surface, minutes	15	20	15
Hard, hours	48	48	48

Table No. 2.—Characteristics of Synthetic Resin (Phenolic) Basing Cements.

Sample No.	3	4	5	6
Source	B	C	D	E
Composition, %:				
Phenolic Resin	100.0	52.5	43.6	27.5
Wood Flour	—	—	51.6	—
Mineral Filler	—	—	4.8	—
Siliceous Earth	—	—	—	72.5
Chalk	—	47.5	—	—
	100.0	100.0	100.0	100.0
Colour	Brown	Light Brown	Black	Light Brown

Table No. 4.—Characteristics of Air-drying Resin/Rubber Varnish Adhesives.

Sample No.	14	15
Source	A	H
Chemical:		
Volatile Spirit (loss, 3 hours at 110°C.) %	85.5	78.0
Total Solids (resin, rubber) %	14.5	22.0
	100.0	100.0
Physical:		
Viscosity Centipoises at 25°C.	250	3,500
Specific Gravity at 25°C.	0.834	0.855
Drying time in hours: Surface	¼	¼
Hard	4	4

Table No. 3.—Characteristics of Resin-treated Papers.

Sample No.	Colour	Overall Thickness, Inches			Resin Content %	Ash %	Substance, Grams/ Sq. metre	Thickness, Paper Base, Inches		
		Max.	Min.	Mean				Max.	Min.	Mean
7	Natural	0.0066	0.0061	0.0066	38.0	0.74	156.0	0.0057	0.0047	0.0052
8	Natural	0.0028	0.0024	0.0026	42.8	0.47	61.3	0.0020	0.0015	0.0018
9	Natural	0.0032	0.0027	0.0030	31.5	0.56	68.5	0.0023	0.0017	0.0020
10	Natural	0.0045	0.0040	0.0042	43.5	0.52	81.5	0.0036	0.0026	0.0031
11	Natural	0.0080	0.0068	0.0075	44.3	0.48	157.5	0.0055	0.0050	0.0053
12	Natural	0.0095	0.0086	0.0091	47.6	0.51	187.3	0.0085	0.0076	0.0075
13	Natural	0.0041	0.0034	0.0037	47.2	0.43	88.7	0.0030	0.0025	0.0027
11a	Black	0.0089	0.0069	0.0077	48.5	0.59	160.5	0.0060	0.0052	0.0055
12a	Black	0.0101	0.0090	0.0095	47.6	0.46	185.3	0.0089	0.0077	0.0078

All samples chemical wood stock base, clean, long fibres. All samples entirely neutral in reaction.

demonstrated, from one source, are typical of those of several origins. The cement is the liquid resin product, and the volatile constituents it contains are mainly moisture and spirit. It is alkaline due to residual condensation agents which assist in its final curing. It is a high viscosity medium which tends slowly to become of even greater stiffness upon storage. The varnish is a lower consistency material and actually similarly constituted solutions can be purchased having resin contents over the range from 20 to 60 per cent. approximately. However, a more customary procedure is to use the high resin content varnish as the stock base and to thin it with a predetermined quantity of industrial methylated spirit (of at least 60 O.P. strength) according to the purpose for which required.

All the cements and adhesives having the curable phenol-formaldehyde type of resin as the fixative base must be set by heat. Conditions of baking depend upon several factors including:—

(a) precise nature of the fixative, that is, composition and consistency;

(b) nature of the materials to be joined; and

(c) service requirements of the seal.

Consequently, they may vary from job to job over quite a wide range, with peak baking temperatures between 50 and 150 degrees C., and heating times from a few minutes up to 72 hours. A number of practical examples can best illustrate these features.

The phenolic cement is suitable for fixing inserts or components that slide over one another. The securing of end-caps, rings, bands and so forth represents a useful field. Tubular fuses for electrical purposes in which the tube may be glass or ceramic and the end cap a metal one of brass, copper, nickel silver, etc., are one example. Another comprises vitreous resistors in which the winding is on a ceramic rod or tubular base, covered with vitreous enamel and the leads taken to circular metal bands or to metal end-caps. A third is typified by the precision oscillators of the quartz crystal type in which the accurately ground crystal is mounted between electrodes in a small glass tube; the accurate mounting of a brass end, and a threaded brass ring around the opposite end, with a permanent cement despite the vagaries of the glass tube dimensions is a fundamental feature of this design. As a fourth can be cited the moisture and waterproof fixing of windows in sensitive electrical apparatus such as photo-electrical devices for operating in open atmospheres.

In any of these applications, the phenolic cement itself can be used provided the width of the interspace is very small. When the gap is appreciable, it is advisable to employ a mineral loaded cement and for still larger interstices to use an intimate mixture of the cement and a wood-flour-filled phenolic moulding powder. These mixtures are used freshly prepared by grinding the "filler" into the cement in a pestle and mortar till uniformity is achieved. In general, the consumption of fixative is small, and the chemical labora-

tory can easily maintain daily supplies of mixture prepared by hand. Where larger quantities are entailed they can more conveniently be produced at regular intervals in a mechanical mixer of the "kneader" type or of the end-runner form of pestle and mortar.

Type of Filler

Regarding the mineral filler for phenolic cements, this should be a fine powder, free from grit, dirt and extraneous contamination. Diatomaceous earth such as kieselguhr, silica flour, china clay, talc and plaster of paris are the chief commonly employed, with the last named most popular. The plaster of paris should be freshly calcined about 160 degrees C. to ensure expulsion of a moisture which, if retained, assists in promoting blistering. Some of the proprietary "white" cements or "porcelain cements" as they are sometimes designated are often preferred to plaster of paris itself. They are apparently produced by controlled heating of gypsum, or by over-heating followed by a sulphuric acid treatment. They are fine soft powders, supplied in sealed containers and therefore of assured cleanliness and uniformity. A 50/50 mixture of the filler and the cement is cited as a good guide, although this can be varied from 30/70 to 70/30 filler/cement ratio to meet individual demands. When a moulding powder is selected as filler, the object is to incorporate a fibrous filler in a simple fashion. Any good quality wood-filled moulding powder of phenolic resin base can be selected, colour black or brown, to suit the need in question. According to the dimensions of the interstices to be filled, it may be necessary to screen the powder before use in order to remove excessively large particles or to obtain a closer range of particle size. Sample No. 5 in table No. 2 has been used in this way.

Fig. No. 1 represents a typical case for the use of a 50/50 mixture of phenolic resin cement and plaster of paris (or white cement). To the small glass tube (A), a metal cap (B) and an externally threaded ring (C) have to be secured at opposite ends. The assembly actually represents a job demanding instrument accuracy, in which the axis of the thread on C and that of the extension screw on B must be parallel and, so far as possible, in the same straight line. Taking into account the wide limits required in glass manufacture, that is, on length and diameter of tube, wall thickness, concentricity of internal and external diameters, and squareness of ends, it may be assumed that the design and accuracy of machining of the metal parts, and the precision of cementing, have not merely to take care of these wide shortcomings, but to overcome them.

The best that can be done with the glasses is to square the ends by wet grinding, the metal accessories being machined to close dimensional tolerances, B with an accurate seating and C with an end face true with the axis of the thread.

Radial clearances between the metal components and the glass should preferably not exceed 1-64 in. (0.4 mm.); where instrument accuracy is not involved, greater clearances, e.g., 1-16 in. (1.6 mm.) can readily be catered for by the cement. Some engineers ask for one or both of the mating surfaces to be roughened by abrasive blasting, this being usually applied to the glass alone; it is not essential, however, for the security of the cementing.

The cementing is performed in two stages, the cap (B) being first securely positioned and partially baked, then the ring (C) located and the baking completed. The mating surfaces of the glass and of B are thinly but completely coated with the cement. They are then brought together with alternately a clockwise and anti-clockwise rotary motion, each movement extending from a quarter to half a turn.

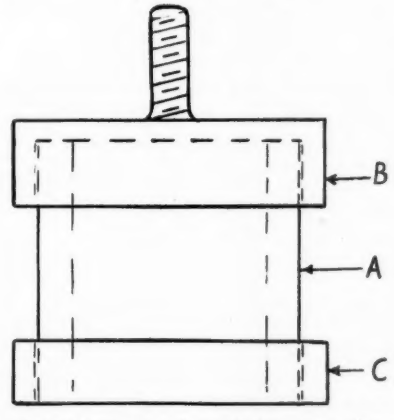


Fig. 1.—Method of cementing end brasses to glass tube.

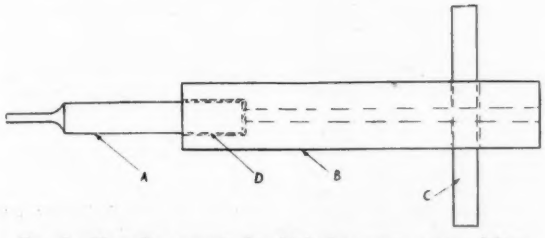


Fig. 2.—Phenolic cement for high frequency screw driver. A and C, H.F. caramic; B, phenolic laminated tube; D, cement.

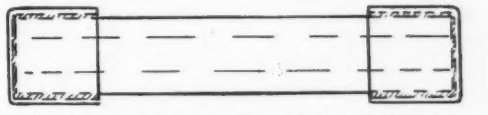


Fig. 3.—Cemented end-caps on tubular glass or ceramic fuse.

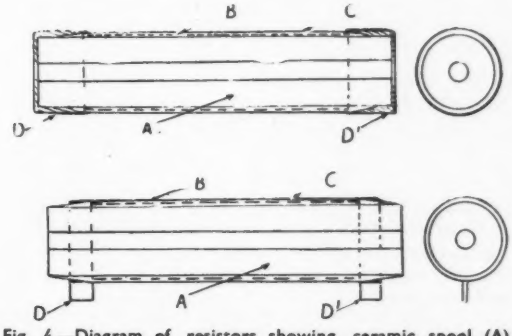


Fig. 4.—Diagram of resistors showing ceramic spool (A), winding (B), vitreous enamel (C) and end-cap or band (D, D¹) fixed with cement.

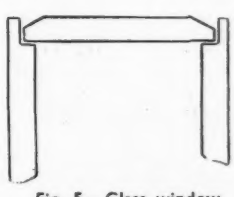


Fig. 5.—Glass window in metal seating for cementing.

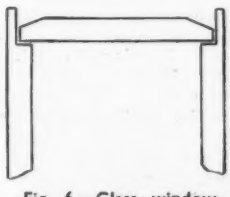


Fig. 6.—Glass window in metal seating for cementing and spinning.

C

Cement forced out of the junction is wiped clean, complete cleaning being achieved with a cloth moistened with methylated spirit.

Assemblies are loaded, open end downwards, on flat metal trays covered with a sheet of paper, and uniformly heated in a thermostatically controlled oven to 60 degrees C. for a period of 24 hours. After cooling, the threaded ring is similarly assembled with cement, but as this time there is no seating to provide for location, the ring, after wiping away excess cement, is squared by forcing down on to a flat surface plate.

Baking is conducted, again with open end down, on paper-covered flat trays, for 24 hours at 60 degrees C., followed by 24 hours' treatment at 70 degrees C. At the end of the baking period, the bakelite resin will be fully cured, insoluble in alcohol, free from blisters, or cavaties, thoroughly moisture-proof and hard. The strength of the junction is such that the brasses cannot be removed from the glass without fracturing the latter.

The same phenolic resin plaster-of-paris cement has proved satisfactory for fixing porcelain components to plastics of the laminated phenolic type. An example is a screw-driver blade of high-frequency ceramic in a tubular plastic handle, as shown diagrammatically in Fig. 2. The method adopted will be described and is equally applicable to resin-to-metal joints.

The two parts are freed from oil with solvent naphtha, the recessed end of the laminated tube filled with cement, and the ceramic part rammed into position, excess cement being thoroughly cleaned off. The tube is filled by plugging with a loosely fitting brass rod so as to isolate the cavity designed to take the cement. The porcelain part is then carefully but firmly pushed into position. The cement which oozes out around the porcelain can be entirely wiped off with 64 O.P. industrial methylated spirit. Baking is carried out for 48 hours at 60 degrees C. followed by six hours at 100 degrees C.

Details of Baking Treatment

During baking, it is necessary to hold the parts together with a suitable fixture, otherwise the cement pushes the porcelain out of position. Again, after the first five or six hours of baking, it is necessary to remove the brass rod from the inside of the tube, otherwise this also becomes cemented into place.

The object of the low temperature, slow-heat treatment is to cure the cement without blistering or oozing.

The finished job exhibits a cemented joint, free from blisters, and thoroughly hard and firm.

There is no reason why a similar procedure should not be adopted for metal-to-porcelain joints. Thus, for tubular fuses and ceramic resistors of the general type shown in Figs. 3 and 4 respectively, it would provide a permanent joint capable of withstanding tropical conditions. The same degree of strength, and a particularly neat appearance may not be required in such cases as this, consequently, the baking conditions can be correspondingly modified (shorter period, higher temperature) to speed up production.

The 50/50 phenolic resin cement/plaster-of-paris mixture can be utilized for fixing glass windows into metal seatings. End glasses in metal tubes are shown diagrammatically in Figs. 5 and 6. The first shows a bevelled glass to be cemented on a seating and to be filled flush with the surround; the second shows one in which the metal tube is to be spun over the glass after the cement is in position. In point of fact, these particular examples required the cementing to be air-tight and to withstand a water test involving the sinking of the glass in water to a depth of 6 ins., no trace of water to enter the tube in 48 hours.

For cementing to the seating without turning over, the following proved a satisfactory procedure:—(a) First application of cement. Minimum amount applied to seating and glass forced into position. Surface allowed to dry. (b) Second application of cement. Excess cement removed; joint and glass cleaned free from cement and allowed to surface dry. (c) Cement given first light coat phenolic resin varnish, e.g., as sample No. 2, Table No. 1 and allowed to surface dry. (d) Cement given second light coat of phenolic resin varnish and allowed to surface dry. (e) Completed job is baked for 24 hours at 60 degrees C. followed by 24 hours at 70 degrees C. If preferred, the cement can be cured by baking 24 hours at 60 degrees C. prior to varnishing, and after varnishing, baking can comprise 8/12 hours at 60 degrees C. followed by 8/12 hours at 70 degrees C.

When a turning-over operation is entailed, a single cementing operation is adopted, the layer being allowed to surface dry, and the spinning operation subsequently performed. Excess cement is then removed, a single painting with phenolic resin varnish resorted to, and then the baking operation carried out. A final painting, preferably followed by rebaking, is advised.

(To be continued)

THE EMPIRE WAR EFFORT

The Delhi Conference to study war supplies in the Eastern Hemisphere which opened on October 25 is being attended by delegations from South Africa, New Zealand, Australia, India, Burma, Ceylon, British Malaya, Hong Kong, the East African territories, Southern Rhodesia and Palestine.

Gifts.—By October 7 gifts received by the Minister of Aircraft Production for the purchase of aeroplanes totalled over £4 million from the Colonies alone and £1 million from the Dominions.

Thousands of pounds have arrived in the U.K. from the Empire for air-raid relief. The first list of the Air Raid Distress Fund published in London showed that contributions from Australia were £393,180, from South Africa £103,840, from New Zealand £81,600, and from Canada £6,150.

CANADA

Army.—The Militia will in future be known as the Canadian Army. The strength of the Army including the Active Service Force is now 286,000.

Navy.—There are now 13,000 men in the Navy, which will increase soon to 20,000 men, 120 vessels now in commission will be increased to 215 in the near future, 15 ocean-going yachts were recently acquired.

Air Force.—The Air Force now numbers 36,000 men; 2,286 men offered themselves for enlistment in the first week of October.

War Industries.

Warships.—£12 million programme planned for four years will be finished in two; six more minesweepers have been ordered.

Aircraft.—Production will be doubled soon and trebled by June, 1941. Workers in aircraft factories increased 40 per cent in the last three months to 11,000. Orders recently taken amount to $35 million. Plant extensions of $5,500,000 have been begun.

Tanks.—3,000 tanks of a new type are to be constructed at a cost of $37 million.

Shells.—Output is now a million a month.

Aerial bombs.—Production will start in February on 500 lb. bombs. One plant alone will put out 100,000 bombs a year.

(Continued on page 273)

Ideas—

By the EDITOR

Chinese Mouldings

Few of us in this country know of the new industrial advances that are taking place in modern China. More's the pity, for, obviously, there is a huge market awaiting exploitation. In the synthetic resin field the Chinese military powers seem to be able to teach us something, since, as the accompanying photograph shows, gas-mask mouth pieces of a design different from our own are being moulded in that country. We presume they are being made in that part of

China not yet overrun by the Japanese, so that the manufacture is still more remarkable. The moulding powder is Durez, the well-known American resin, and is stated to withstand any of the poison gases now being used in warfare. Judging from the above example, there is little we can teach the Chinese in moulding.

Transparent Aeroplanes

If one wishes to dwell on a further horrible stage in modern technical development, otherwise on steps in civilization, one can reflect that the time is not far distant when a bright lad, fed on H. G. Wells, will start work on making the invisible aeroplane; that is, invisible so far as wings and fuselage, etc., is concerned, leaving engines and pilots, etc., visible and thus giving enemy craft a much smaller target to aim at. We presume this will be possible one day, perhaps not from cellulose-acetate sheeting or similar material, but from the transparent polymerized type of plastic. I visualize the time when so much is known about these materials that we shall be able to make a transparent sheet of any desired refractive index. Some of these materials are amazingly strong and high price is at present a deterrent for many jobs, but when we consider that it has been stated in America that, under certain conditions of very large production, synthetic rubber can be made for 1s. per lb., it gives one furiously to think.

Perfidious Columbia

Yet another example of how the United States is undermining the morale of old England and stealing her workers and ideas is given in a blatant photograph sent us by Monsanto Plastics Division of Springfield, Mass. Unless, of course, it is all a cunning export device on the part of our Board of Trade to make American dollars pay for our war.

It is probably true that the original patent for making muffins expired some years ago, but it is also highly

probable that the shrewd Americans lured with stupendous bribes a famous muffin tosser (or am I thinking of crumpets?), complete with the machinery for making the tiny holes, to go to America. This may, of course, explain the complete absence of the succulent muffin in English baker-shops. Gone, too, I notice, are the dulcet tones of the muffin-man's bell.

Of course, we don't believe Monsanto is the cause of all the trouble. Their cellulose acetate Vuepak, at any rate, keeps the muffins fresh and clean.

British Industrial Plastics

The report of British Industrial Plastics, Ltd., covering the year to September 30 last has been issued. Gross profits have risen to £163,069 by comparison with £110,631 in 1938-39, although heavier expense items and a substantial advance in tax charges (from £20,000 to £56,500) leave net profits showing relatively little alteration at £23,198, against £21,959 in the previous year. The ordinary dividend is the same at 8 per cent. and the balance forward is raised from £3,677 to £5,681. In his survey accompanying the report, Mr. Kenneth Chance, the chairman, stresses progress made in export markets despite conditions of exceptional difficulty.

American Developments with Thermo-Plastics

The United States, Working Under Comparatively Peaceful Conditions, has been able to Push Ahead with Important Scientific and Technical Productions

FEW recent developments in plastics seem likely to have more far reaching results than that announced by the Dow Chemical Co. in the form of a new plastic to be marketed commercially in fabricated form under the trade name of "Saran." This new plastic is designated technically as vinylidene chloride and its primary use is to be in the production of seat coverings woven from the extruded material and intended initially to take the place of rattan. A primary and very extensive use of rattan is for the covering of seats and back rests in subway cars and other public conveyances. Although the natural fibre when woven into such cushion covering has been considered the best available for the purpose for many years, it has many drawbacks which are overcome by the new covering woven from plastic. Rattan absorbs dirt, since it is porous, and is difficult to keep in clean and sanitary condition. In addition, it is subject to splitting and cracking which often results in damage to clothing, especially women's hosiery. It is also easily cut and is often damaged by vandals. Deterioration in appearance is rapid and cannot be restored by cleaning. All these disadvantages are said to be overcome with Saran, which is highly flexible, exceedingly tough and is said to have a tensile strength equal to that of mild steel, namely, up to 60,000 lb. per sq. in.

General Properties of Saran

Life of the new material is said to be long. It does not split or crack. It is non-porous, hence dirt remains on the surface and is easily removed by soap and water without damage to the material, which retains its colour and lustre. There is no limit to the range of colours available, hence appearance over rattan is greatly improved. The material is non-inflammable and is said to be unaffected by exposure to weather. Being exceedingly tough, it is resistant to slitting by vandals. Flexibility is said to be unusual and availabilty in continuous lengths make for convenience and economy in weaving. Both the raw materials, which are widely available, and the plastic are described as low in cost.

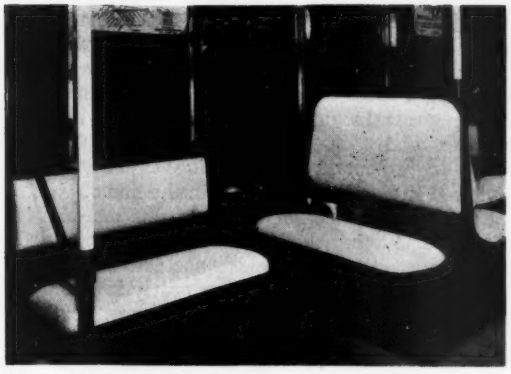
Several companies beside the Dow Chemical Co. contributed to the success of producing extruded Saran and of applying it for seat coverings. Irvington Varnish and Insulator Co. helped to develop special methods and equipment for extrusion, providing close control of temperatures, pressures and speed of extrusion to ensure a product uniform in character. The Heywood-Wakefield Co., weavers of seat coverings and makers of complete seat units, contributed experience in fabricating the material, finding it capable of faster handling and much more uniform in size and quality than rattan. They contributed a method of pre-forming corners after weaving, presumably to shape the corners of cushions. Another organization, Firestone Rubber and Latex Co., makers of "Airtex," a cellular latex material developed for cushions, co-operated in adapting such cushions for use with Saran. The result is a plump, well formed and comfortable seat with a porous structure which allows of free air circulation to promote coolness and sanitary conditions.

Either simple one-colour or more elaborate multi-coloured designs are readily produced in weaving and make the material available for decorative effects as well as for bringing the benefits previously stressed. Saran has already been applied in some New York subway cars and has resulted in important improvements in appearance among the other advantages.

The use of Saran is not confined, of course, to the production of seat coverings, although its first large application is in this field. It has been used as leaders and lines in commercial and sport fishing, because it is strong both when wet and when dry. In some forms it becomes invisible in water and is expected to displace Japanese synthetic gut and Spanish silkworm gut leaders. Application in woven, twisted and braided strands may become almost unlimited as the material lends itself to other forms of materials than those produced by extrusion. The material is described as a "pure" thermo-plastic. It has already been applied as a bonding agent in a new type of abrasive wheel.

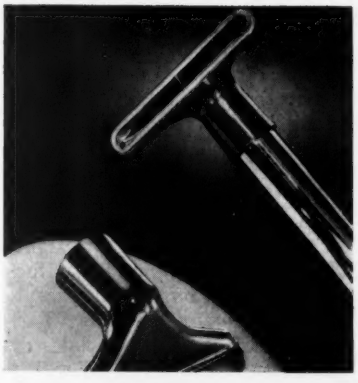
Mechanical and Electrical Properties of Saran Resins

Moulding Properties:	
Compression moulding temperature	220-350°F.
Compression moulding pressure ...	500-3,000 lb./sq. in.
Injection moulding temperature ...	275-350°F.
Injection moulding pressure ...	5,000-40,000 lb./sq. in.
Mould shrinkage	0.013 in. per in.
Physical Properties:	
Specific gravity	1.6-1.75
Specific volume	17.3-15.8 cub. in./lb.
Refractive index	1.60-1.63
Tensile strength	Up to 60,000 lb./sq. in.
Elongation	25 per cent.
Modulus of elasticity	Up to 2.4 x 10^5lb./sq. in.
Flexural strength	15,000-17,000
Impact strength (Izod unnotched)	1-4 ft. lb.
Thermal conductivity	0.0002 C.G.S. units
Specific heat	0.32
Resistance to heat	160-200°F.
Softening point	200-325°F.
Distortion under heat	150-200°F.
Tendency to cold flow	Slight
Volume resistivity	6 x 10^{13} ohm-cms.
Breakdown voltage, 60 cycles ...	500-2,500 volts/mil.
Dielectric constant, 60 cycles ...	3.0-5.0
Dielectric constant, 10^3 cycles ...	3.0-5.0
Dielectric constant 10^6 cycles ...	3.0-5.0
Power factor, 60 cycles	0.03-0.08
Power factor, 10^6 cycles	0.03-0.05
Water absorption	0.00 per cent.
Burning rate	None
Effect of age	Becomes stronger
,, ,, weak acids	None
,, ,, strong acids	None
,, ,, weak alkalis	None
,, ,, strong alkalis	None
,, ,, sunlight	Slight
,, ,, organic solvents	Highly resistant
,, ,, metal inserts	Inert
Machining qualities	Excellent



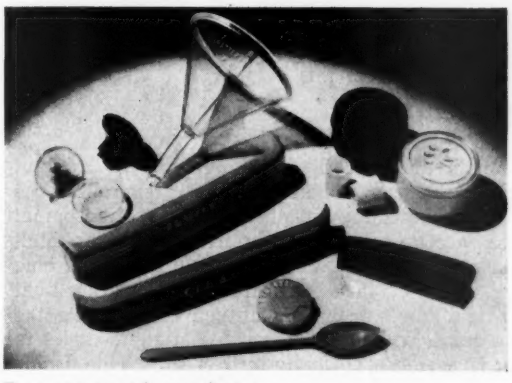
New York train seats covered with extruded Saran.

Abrasive wheels using Saran as a bonding agent.



Vacuum cleaner nozzles of Tenite, cellulose acetate. They are normally made of metal.

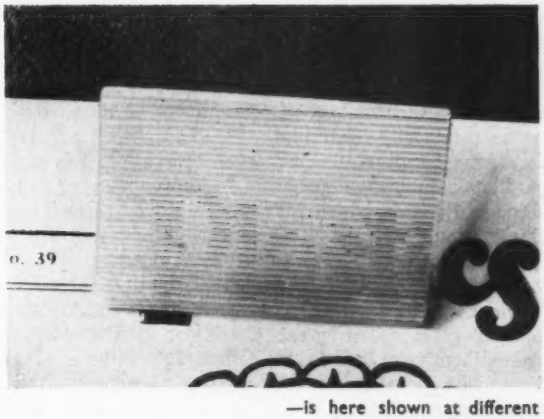
Boudoir chair of Lucite, cast acrylic resin, enhances the beauty of the bedroom.



Transparent and translucent mouldings from Dow's Styron.

Dow's ethyl cellulose is used now for many mouldings.

This sheet of Louverglas made from Du Pont's cellulose acetate—



—is here shown at different angles, to give diffused light.

Parts produced from Saran by compression and by injection moulding are said to have met with unusual success at critical points in industrial and chemical plants. Resistance to solvents, to channelling and to abrasion as well as the chemical inertness of the material contribute to its success in such applications. High dielectric strength and ease of machining are among other properties making the material of interest for certain types of application. The range of physical properties as furnished by the makers are given in an accompanying table, and accompanying illustrations show some applications already made.

Dow's Styron and Ethocel

Another thermo-plastic produced by Dow Chemical Co. is called Styron, a polystyrene of high purity. As is now well known, among the properties of polystyrene are high chemical resistance and exceptional resistance to water. Its specific gravity is 1.05, the lowest of any commercial type of plastic. Applications to date include funnels for photographic and other chemical uses, handles for containers in domestic refrigerators (where low moisture absorption is a factor), for door knobs, spoons, low-loss dielectric parts, bottle caps, combs and the like.

Considerable experimental work has been done in the use of Styron for transparent and translucent building "blocks" or moulded sections, but information at hand does not indicate whether this type of product has reached a commercial scale. It is believed, however, that, if cost can be brought within required limits, applications in place of glass may prove feasible, especially as the product is so much lighter than glass and so much less fragile.

Still another Dow thermo-plastic, known as Ethocel, ethyl cellulose, is gaining wider use. It is suitable for injection and for compression moulding and, in its extruded form, is produced in strips suitable for a wide range of uses, among them being woven and other parts of porch furniture. The same basic materials made in the form of foils which are transparent is used for wrappings, moisture-proof bags, films for electrical insulation and the like.

New Uses for Lucite and Plastacele

E. I. du Pont de Nemours and Co., one of the largest American manufacturers of chemicals, as well as of several forms of thermo-plastics, finds the use of these extending rapidly. The oldest of these plastics is nitrocellulose sold under the name Pyralin, which continues in large production. Plastacele (cellulose acetate) is growing in importance along with the extending use of injection moulded parts, especially for decorative parts of motorcars. A great deal of attention is centred also on Du Pont's Lucite plastics in the methyl-methacrylate classification. "Piped lighting" applications are extending and have even been applied in such products as petrol pumps, that is, the vending units at filling stations, in which Lucite is employed to facilitate illumination of the dial from concealed light sources.

Lucite has entered the furniture field, especially for making rather expensive boudoir chairs and for tables in which the legs are of transparent Lucite rod and the tops of glass. The great clarity of acrylic plastics makes them popular in crystal-clear decorative applications, such as parts for shoes, costume jewellery, tableware and ornamental home accessories as well as in fixtures for window and other displays.

One of the most recent developments in Plastacele is a sheet material termed Louverglas, designed especially for use in lighting fixtures. It is manufactured by Du Pont from Plastacele for the Doane Products Corporation, makers of lighting equipment, and is intended especially for use in combination with fluorescent light sources now gaining extensive use. When viewed straight on, that is, with the line of vision at right angles to the face of the sheet, the material is transparent except that there appear to be, as if ruled on the surface (although they are not actually in the surface), fine parallel lines which are nearly invisible at a distance. In reality, the lines, or "louvres," extend nearly or quite through the thickness of the sheet. As the angle of vision changes the louvres cut off direct light and pass only diffused light, causing the sheet to appear translucent rather than transparent. Thus, if the sheet be placed horizontal with a light source above it, only those rays which (in a given plane at right angles to the lines and sheet) strike the sheet at right angles, ranging, for example, from 90 to 45 degrees, will pass through the transparent portions. Other rays will strike the louvres and be diffused. The thicker the sheet, the "earlier" the cut-off as the angle of vision decreases. In effect, the louvres may be likened to a venetian blind in which the respective slats are translucent and are held parallel to themselves, but all at right angles to the window. When viewed straight on, virtually all light passes through, but when the angle of vision is acute, the slats cut off all light except that diffused by the translucent body of the slats. The purpose of the sheets, which can be had in thicknesses of 0.040, 0.060 and 0.080 in., is to prevent glare by direct rays from a light source, for the usual angle of vision, but to permit most of the light to pass through the sheet at other angles and thus to illuminate directly objects which receive this light.

Structure of Louverglas

Although the method of making Louverglas is not revealed, it appears to be made by stacking and at the same time cementing together sheets of transparent cellulose acetate which have been "ground" or sand-blasted or which have a corresponding light-diffusing surface. If sheets then be cut from the block thus built up, at right angles to the face of the original sheets, the ground joints will form the louvres at right angles to the surface of the newly formed sheet. Thin facing sheets may be applied each side of the louvred sheet to strengthen the latter and to give it the perfectly smooth surface which the samples reveal. If the ground faces or louvres be coloured, as they are in some forms of the product, diffused light passing through the louvres is correspondingly tinted. This makes it possible to create various colour effects and also to "correct" the light from a source lacking, say, in red rays, by colouring the light which passes through red or pink tinted louvres. Other special effects are secured by using two sheets of Louverglas so placed that the louvres in one sheet run at right angles to those in the other sheet. By embossing the sheet on one surface to give a prismatic finish, the prisms, made 40 to the inch, obscure the interior construction of a fixture in which the sheet is used and are said to prevent eye strain or bright images.

Louverglas is reported in extensive use already for desk lamps and lighting fixtures in banks, railway cars, display rooms, museums, drafting rooms, beauty parlours and the like and several forms of pendant

fixtures are now commercially available with the new form of "glass" as an important feature.

Du Pont, as well as Rohm and Haas (the latter making Plexiglas and Crystalite, both from acrylic resins) are understood to be furnishing sheet material for aircraft cowlings and windows in large quantities. Although Du Pont is turning out large quantities of Nylon, especially for knitting hosiery and for fabrication of bristles for brushes and surgical sutures, fishing line, and the like, no commercial applications of Nylon in moulded, sheet, rod or tube form have been announced.

Among the most important of all American thermo-plastics is the polyvinyl acetal sheet employed as the sandwiched layer in the manufacture of safety glass. This material has now largely displaced acetate sheeting formerly used for the same purpose, largely because it is stronger and retains its flexibility at low temperatures. It is produced by Du Pont, by Carbide and Carbon Chemicals Corp. (with whom the Bakelite Corporation is now affiliated) and by Shawinigan Chemicals Corp., partly owned by Monsanto. Comparatively recent is the use of flexible and elastic vinyl sheet or strip material for belts, garters, braces and wrist-watch straps, most of which are made in transparent or translucent form with little or no colouring.

Additional Progress in Cellulose and Vinyl Plastics

Tennessee Eastman Corporation continues as one of the largest producers of cellulose acetate, the moulding form of which is called Tenite I. It also manufactures cellulose acetate-butyrate, called Tenite II, both for injection moulding and for extrusion into ribbons or strips. Extruded Tenite II has been used in the manufacture of woven porch furniture in place of rattan and reed, as well as in other applications. Cellulose acetate-butyrate is less subject to water absorption and much more resistant to weathering than cellulose acetate. Both materials are used extensively for injection moulding and to some extent also for compression moulding.

Another large producer of thermo-plastics (as well as of thermo-setting plastic) is the Plastics Division of the Monsanto Chemical Co. Relatively few years ago, Monsanto took over the Fiberloid Corp., makers of cellulose nitrate and fabricators of cellulose acetate, which are continued, as are also cast phenolics. Also made now are vinyl acetal and polystyrene plastics. One of the Monsanto cellulose plastics is now being used as a coating for cord, the new product, called Cotacord, having been developed by Freyberg Bros. for use in making such products as belts and sandals, woven or braided from the cord.

Highly plasticized vinyl plastics, made by Carbide and Carbon Chemicals Corporation, are now being used in combination with leather for making shoes, handbags and similar products. This plastic material is said to be permanently elastic and proof against water, perspiration, cracking and scuffing. Raincoats and other stylish garments such as smocks in transparent effects are being made in a material called "Exylin" by McCoy, Jones and Co., using material furnished by Carbide and Carbon Chemicals Corp., and prepared from resins of the vinyl type.

There are on the American market numerous other products recently fabricated from thermo-plastics and some of which are illustrated here. It will be apparent from this brief outline, however, that the use of thermo-plastics is increasing both in the extent and in the variety of products turned out. More materials are being made available constantly and there appears to be no end to accomplishments which depend upon plastics to make them practical or commercially successful.

THE EMPIRE WAR EFFORT *(continued from page 268)*

Output of steel.—Canada is now producing more than 2 million tons a year, double the rate in the last war.

Electric Power.—New developments on the St. Lawrence will generate about 2 million h.p. The cost will be divided between the United States and the province of Ontario.

Food Supplies.—A Canadian Mission arrived in the U.K. on October 6 to discuss exports of more food for Britain from Canada. Canada has enough wheat to supply Britain for three years; 70 per cent. of Canada's production of cheese is being sent to the U.K.

Exports.—Canadian exports to the U.K. alone have risen by 36 per cent. in the first year of war over 1938-9. Canada is now third among the exporting countries of the world.

War Expenditure.—Total value of war orders placed in the Dominion to the end of September was $390 million for Canada and $134 million on account of the U.K. October's orders brought the total for Canada to $550 million.

AUSTRALIA

A War Council of eight members has been set up representing both Opposition and Government.

A new Department of Labour and National Service has been created to deal with problems of labour, industrial relations and the effective use of man power to win the war.

Broadcasting of news in foreign languages is transmitted from Australia for the French Pacific Islands, Indo-China, the Netherlands East Indies and other places in the Far East.

Army.—The call up of the age group 20 to 24 brought 62,000 men for the Militia. This and 43,000 volunteers previously asked for will bring the Militia to full strength of 210,000; 50,000 have been training in Militia camps this month and another 50,000 will be called for training immediately.

Air Force.—A number of bomber and fighter aircraft of the R.A.A.F. have arrived at Singapore.

Total applications for enlistment are now 132,215. Total strength of the R.A.A.F., including reservists, is now 40,000, 11 times as much as in September, 1939; 1,200 recruits a month will soon be called up and 20,000 of the 26,000 ground staff required are on duty.

War Industries.

Warships.—Millions of pounds have been spent on naval construction, including two Tribal class destroyers and 10 minesweepers.

Aircraft.—The hundredth Tiger Moth trainer was handed over at the beginning of October. Production of training machines is now two a day for elementary and one a day for advanced training.

Motor vehicles.—14,000 vehicles are being constructed costing over £3 million.

Howitzers.—Production of 25-pounder howitzers is being planned.

Shells.—Production of 9 million shells a year is expected when the industry is fully developed.

Machine tools.—The number of firms engaged on producing machinery necessary for war industries has increased from 3 to 28 and the number producing tools, gauges and fixtures from 8 to 85.

Magnesium factory.—A company with a capital of £500,000 is erecting a factory to make magnesium which will be the third largest producing plant in the Empire, yielding a thousand tons a year.

Raw Materials.—The amount of Australian wool to be stored in the U.S.A. is 250 million lb., valued at £A15 million.

War Expenditure.—Australia spent £A10 million on war services in September. Expenditure for 1940-41 is estimated at £A177 million, including £A145 million to be spent in Australia.

REFRIGERATION ENGINEERS ADOPT PLASTICS

The glazed sliding doors in this industrial refrigerator have been moulded from phenolic resins.

IN our November issue we gave some publicity to the fact that plastics are now beginning to be seriously considered as materials of construction in the refrigerating industry and not merely as pretty although useful addenda in the shape of door handles and so on. In other words, they are being used because they can be formed into strong mouldings which possess in themselves reasonable insulating properties.

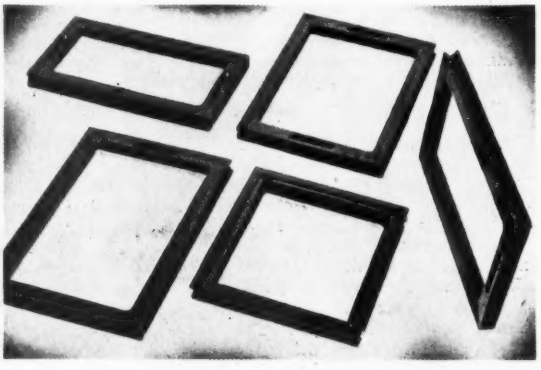
An excellent account of these latest developments is given in the September, 1940, issue of *Modern Plastics*. The well-known concern of Hussman-Ligonier, after some considerable research work, has adopted moulded sliding door frames and rails for their commercial refrigerators. Using a special phenol-formaldehyde resin moulding powder a range of five different sizes of door frames—19 ins. by 28 ins., 19 ins. by 25½ ins., 10 ins. by 20¾ ins., 14½ ins. by 25½ ins. and 14½ ins. by 28 ins. have been produced, completely satisfying the physical and mechanical requirements of the job. The rails upon which the sliding doors run have been moulded in lengths, 40¼ ins., 49¾ ins. and 54¾ ins. The choice of plastic was made with the following properties in mind. It was necessary for the door frames to be stoutly built to withstand continually sliding backwards and forwards; the plastic had to provide insulation between the inside cold and the outside room temperature; there was the problem of avoiding condensation on the outside surface of the door; low weight was fairly important in order to permit ease of handling and possible saving in transport, and finally the constructional material had to withstand constant cleaning with soaps and any other solution that might be used for the purpose.

The moulding of the frames has been especially carefully carried out, for it was imperative that the movement of the doors must be smooth and that warping should be avoided. These requirements were met by the design of the mould, the technique of moulding, the type of moulding powder and the provision of cooling devices.

As will be seen from the above photograph, the door frames have been glazed. There are obvious difficulties in utilizing the conventional methods of mounting glass on plastic frames, but the insertion of screws to hold the glazing strips in place was solved by the use of rubber plugs in the body of the door.

The rails on which the doors run offered little difficulty, the main consideration being a strong and non-warping structure.

The example here described is just the beginning, we hope, of a new sphere of engineering in which plastics will take an ever-increasing part. We are anxious to see a properly considered opinion of plastics, by refrigeration engineers, as to their position, vis-à-vis the older and well-tried insulating materials.



The moulded frames are made in five sizes. They are cored for reduction in weight.

PRODUCTION

Practical Information dealing with Raw Materials, Moulding and Forming of all types of Plastics—Thermo-Hardening and Thermo-Plastic—Works-Organization, New Plant and Control Apparatus

NOTES AND COMMENTS

Moulding Without Moulds

THERE is little need to reiterate the oft-repeated statement that the cost of moulds prevents the production of many interesting jobs which, because of the small number required, cannot possibly be made economically in plastics. Many processes have been attempted to produce moulds cheaply with varying success. An excellent example was given in our August, 1940, issue which described a process of spraying metal around a form, removing the sprayed metal shell and suitably backing it to form a rigid die. Judging from the photographs we published, the detail obtained was excellent and the moulds are stated to stand up very well in test performances.

There is now a new method of moulding and pressing which employs no mould whatsoever, or, rather, no conventional and specially prepared mould. It can be employed both as a process of curing an already formed shape or moulding and curing a shape.

The new process is one of shot moulding and has been well described in a recent issue of the *Electrical Times* by R. I. Martin, M.I.E.E., and while its application may at first sight appear somewhat limited, yet we feel sure it will open up spheres of industry which have not yet been tackled.

The application is particularly suitable for the production of certain electrical jobs, for pressing coverings on to the outer surface of articles.

Shot moulding is carried out by the use of hot steel shot (approximately 40/1000 in. diameter), which, acting as a fluid, provides both the heat and the even pressure necessary to carry out the curing and forming around the matrix or within the shape it is desired to copy. The part to be pressed and cured, for example, a field coil encased with synthetic-resin-treated fabric, is covered with a protective sheet such as rubber, in order to prevent the small shot adhering to the resin. The protected coil is then placed in a metal moulding box, the space between the object and the sides of the box being filled with hot steel shot. A plunger, situated in the top of the box, is actuated by external hydraulic pressure, which is thus transmitted to the shot and so to the heated resin-covered object. The temperature and pressure is maintained for about half an hour to ensure curing, after which time the object is taken from the box and the rubber covering removed, leaving a well-bonded synthetic-resin-fabric compound. The covering of shaped objects would appear to be the best application for the process and the production of tapered tubes, which cannot be made by the usual machine-rolling methods, is especially indicated. Moreover, of outstanding importance is the possibility of pressing protective coverings on to airscrews.

Obviously the method is not limited to coverings. The moulding of hollow articles, such as boxes, etc., can be made. A plastic-bonded shrapnel helmet, using a standard steel helmet as the mould, has been produced. The use of what might be called a fluid plunger is obviously of absorbing interest, since undercuts inside boxes may readily be made, avoiding the difficulty of removing internal mould parts.

Moulded Doors

A WRITER in the *Contract Journal* deals with our industry under the title of " The Truth About Plastics and Substitute Materials." He repeats the statement so often used by those outside the industry that, for constructional work in building, costs would be prohibitive. Although there is no practical evidence, we believe that the subject cannot be discussed reasonably until constructional engineers take up the problem in a very broad way and include in their calculations not merely cost of resin against cost of steel or wood, but general saving in weight, redesign of entire structures due to this, and the advantages gained through provision of waterproofing, warmth, permanence and other properties.

Somewhat illogically to his own argument, he appears enthusiastic for the moulded door, for he writes:—" In an ordinary door, such as one sees in an hotel or dwelling-house, there will be not less than a dozen pieces. Generally it is many more. These have all to be shaped by wood-working machinery and cut to size before fitting up. The work of fitting up involves a good deal of mitring and the finished job will be no good if the timber is inadequately seasoned. The same may be said of many other components used by builders, and in all such cases the labour cost is many times the material cost. Any such component can be moulded in two pieces and produced by the thousand with absolute precision."

However much we agree with this, we cannot, by the ordinary moulding process, produce a door comparable in price with the wooden variety. Given a door 1½ ins. thick by 6 ft. 6 ins. by 32 ins., it would entail a weight of roughly 125 lb. to 135 lb. for a flush door, and a weight of, say, 100 lb. for one with large panels to save weight. Thus, for raw material alone, the cost is in the neighbourhood of £4 to £5. The solution at present, then, would not seem to be the moulded variety from moulding powder.

Injection Moulding Costs

By D. A. DEARLE

The Author Explains How Several Hidden Factors can Introduce Serious Faults in Injection Moulding Cost Compilations

IN calculating prices for the manufacture of compression moulded parts the matter of raw material loss, as found in fins or flash, is recognized to be quite a factor, but this component of the total cost actually represents nothing more than the difference between the gross and net weight of the piece being estimated. The amount of flash may vary anywhere from 5 per cent. on very large parts to as high as 25 per cent. on smaller ones; but regardless of the percentage, the overflow is scrap, accepted as such, and hence written off on the estimate sheet accordingly. The thermo-plastics, however, present a different problem entirely with regard to flash, for instead of fins there are sprues, runners and gates. Theoretically, injection moulding should utilize every ounce of powder and leave no scrap whatsoever, but, unfortunately, this condition does not hold true in actual practice. In spite of all arguments advanced to the contrary, the realistic moulder has to take into consideration a certain loss of material when figuring on an injection moulded part. Of course, this loss is arrived at in an entirely different manner than that used in thermo-setting parts, but it is there, nevertheless.

Errors of Theory

When the injection moulding process was comparatively new to the plastics industry many optimistic moulders were prone to consider any shrinkage of raw material as negligible. The usual method of calculating costs was based on the theory that, inasmuch as no chemical change whatsoever occurred during the moulding operation, practically all of the material purchased would be utilized in making the finished product. While this assumption was, perhaps, technically correct, it was soon discovered that many unforeseen factors had been overlooked. In the first place, it was found that change from one colour to another could not be accomplished without obtaining a large number of pieces constituting a mixture of the two colours. Then, too, even if only one colour were used, the scrap, owing to loss of a certain amount of plasticizer, had to be mixed with virgin material to gain the desired results, and when transparents were specified, the reground sprues and runners would appear cloudy on the second run. It did not take long to learn, too, that all dirty material had to be carefully separated from the scrap before regrinding. These were only a few of the hidden difficulties which had to be accounted for when the costs were compared with original estimates, and it took a great deal of time and experience to expose finally the many fallacies in the original conception of negligible material loss. Let us now consider some of these conditions in greater detail.

Loss Figures

The ratio of scrap to moulded item is generally much higher in the thermo-plastic than in the thermo-setting compounds. This is due to, (1) the necessary use of sprues and runners, and (2) the fact that injection moulded objects are smaller. Where an average of 10 per cent. for flash is allowed on a compression machine, a figure of 25 per cent. for scrap is really low (and in many instances may run as high as 50 per cent.) on very small injection parts. Even though it be assumed that specifications called for one colour only on a particular part, a large percentage of the original powder has to be reground. This means that the virgin material gradually becomes thinned out as it mixes with second and third-run compound. Each time the material is reground, however, it gets harder and ultimately loses a certain amount of its original colour. Neither burned nor dirty pieces can be mixed with clean scrap, and, therefore, they must be either considered as a loss or put aside to be salvaged when mixed with black. Consequently, there is a definite amount of material which apparently can never be used in making the product for which it was originally purchased.

Unfortunately, there are very few orders given for injection moulded parts which specify one colour only, and in the circumstances allowance has to be made

for the change-over from a blue to a red, a green to a black, or some other such colour change. Apart from the thorough cleaning which has to be given the feed hopper, a great number of shots have to be made in a mottled material before the pieces are again ejected in a uniform and true colour. If transparent shades are included in the order, the number of parts which have to be rejected are even more numerous than when changing from one opaque colour to another. In many cases it is found necessary to run a certain item in two or more of the different thermo-plastic materials, such as acetate and polystyrene, for instance. These materials, being incompatible, make it imperative that the cylinder be thoroughly cleared of one powder before the following compound can again make satisfactory pieces.

The Cost of Grinding Operations

So far no mention has been made of the grinding operation, and this is actually an indirect labour charge which directly affects raw material costs. In compression moulding an allowance usually expressed in cost per thousand pieces is made for preforming, and, by the same token, the grinding operation has to be added to the price of thermo-plastic compounds. Where a grinder is installed close to the operator he is often able to feed the machine during his moulding cycle, but this situation is the exception rather than the rule. Some moulders break off the runners from each shot while they are warm, fold them over and immediately throw them back into the lower feed cylinder of the machine. This practice would appear to be economical, and perhaps is from the standpoint of saving a grinding operation. The plunger, however, is given an additional burden in pushing through the large lumps of hardened material, and very often the saving realized is more than offset by expensive maintenance repairs caused by breakage of interior parts. Furthermore, the amount of powder load has to be constantly adjusted to compensate for this method, and hence many shots are apt to be lost during the process.

If the excess material is handled by an outside concern it costs approximately 3d. a pound to grind, and at such a rate this figure must be added to the price of a certain percentage of the original quantity of powder purchased. Furthermore, the average grinder is limited with regard to the cross-section it is capable of handling. The large annular deposits and free shots of material have very thick sections, and are often too large to put through the medium-sized machines. In addition to this, it must be remembered that the grinder requires a very thorough cleaning each time a different colour is run through it. This operation is not necessarily very expensive, yet has to be recognized, for it definitely reflects as either an added cost of the raw material or an increased overhead figure.

Unless meticulous care is exercised in all of the operations relating to moulding and grinding, dirt or oil spots are bound to get into the material. Even though every precaution be taken, this condition can seldom be avoided with the light shades and consequently there will always be a certain percentage of the finished product which can be neither used nor reground. While the loss thus caused is relatively small, it contributes to the general fund of hidden expenses.

It is during the summer months that the moulder of injection parts encounters his greatest difficulties. Even in cold weather there are innumerable troubles which have to be overcome in order to maintain maximum efficiency, but in July and August the moisture in the air plays havoc with the normal injection moulding cycle, due, of course, to the hygroscopic property of thermo-plastic materials. In order to combat this humidity it is often necessary to use heating ovens and thus dry out the material by artificial means, but when this procedure has to be resorted to, the extra amount of labour involved must again be charged to either the cost of raw material or overhead expenditure.

Press Maintenance

One more element of cost which enters into the calculation is that of press maintenance. Injection machines not only involve a substantial investment at the outset, but also require expensive repairs when such have to be made. Of course, repairs can be kept to a minimum by exercising care in operating, but sooner or later they have to be made. From the mechanical construction of the machine it is obvious that the interior components are under a constant strain during the moulding cycle and the high pressures plus the telescoping action of plungers ultimately result in necessary repairs. When these have to be made, not only are the replacements expensive, but valuable production time is also lost.

So it can readily be seen that the computation of injection moulding costs includes a wide diversity of obscure expenses. Unlike the thermo-setting compounds, the thermo-plastics, acetates, styrenes and acrylates are reworkable after moulding and therein lies the pitfall in preparing the estimate. Due to the fact that the thermo-plastic compounds are much more expensive than either the phenolics or ureas any errors in figuring raw material costs become further accentuated, and hence it behoves the efficient moulder to give serious consideration to this phase of the business. It is, of course, impossible to define any hard and fast rule regarding the percentage of loss to be applied to the cost sheet in view of the numerous conditions as outlined. One fact is evident, however, namely, that net weight multiplied by the powder price is insufficient to cover all the additional expenses involved and a certain "mark-up" has to be made if a true cost is desired. Each plant operates under its own particular conditions and in the final analysis it will be found that experience chiefly determines the cost of producing the goods. On the basis of this experience, however, subsequent estimates will undoubtedly prove to coincide more closely with actual costs.

Lighting of Factories

Crompton Parkinson, Ltd., has sent us some notes regarding the importance of improved lighting in factories, especially under war conditions, and the results of Crompton lamps produced especially for the purpose. The photograph reproduced below shows an excellent example of good lighting using Crompton fluorescent lamps in dispersive reflectors.

PLASTICS RESEARCH IN RUSSIA

Notes on Developments that have Received Little Publicity in English-speaking Circles

RESEARCH work on plastics published in Russia, though much more extensive than that in other countries, resembles the latter in being scattered through a number of scientific and technical journals. All this work is only very incompletely dealt with by the abstracting journals, and a lot of interesting and useful information thus escapes the attention of the plastics manufacturer and of the research worker. This lack of references would make the preparation of a review of Russian investigations on plastics an extremely difficult task, which at the same time would be limited by the impossibility of searching through the original literature, which, in many cases, is not, or is only partially, available.

In what follows, no attempt has been made to present any form of coherent review. Rather has it been the intention of presenting summaries of several articles recently published in Russian journals available in this country.

Production of Polyvinyl Compounds

A typical piece of research work carried out by S. N. Ushakov and A. M. Itenberg is described in *Zhurnal Prikladnoy Khimii (Journal of Applied Chemistry*, XII, 1939, No. 6, pp. 862-866), and was directed at obtaining some preliminary data regarding the production of polyvinyl acetal. This material and the corresponding formaldehyde derivative are of interest as they constitute up to date the best known substitute for natural shellac in the production of gramophone records. Both these materials are produced by the Shawinigan Chemicals, Ltd., and marketed under the names of Alvar and Formvar respectively. The advantage of these materials as compared with Vinylite produced by the Carbide and Carbon Chemicals Corp. are their resistance to flow under small loads, and better retention of shape of the grooves, as well as greater permanence of chemical composition.

The method of synthesis adopted by the authors involved the acid hydrolysis of polyvinyl acetate with simultaneous acetalation with acetaldehyde. Some preliminary work was carried out on the rate of hydrolysis of the acetate on boiling a 25-per-cent. solution with 1 per cent. sulphuric acid.

In the subsequent experiments hydrochloric acid was added in a concentration equivalent to 2 per cent. of the whole mixture. The hydrochloric acid was added in the form of an alcoholic solution to the alcoholic solution of polyvinyl acetate, the final concentration of which was made to be 25 per cent. Afterwards the acetaldehyde was added in the form of paraldehyde and the mixture boiled for 10 hours. The extent of the reaction was determined by titrating the free acid and determining the amount of ethyl acetate formed. The polyvinyl acetal could be obtained in a filterable and washable form by diluting the reaction mixture with at least three times its volume of ethyl alcohol and pouring into water. The mixture was neutralized with an excess of sodium bicarbonate and the acetal filtered off, washed with water and vacuum dried at 98-100 degrees. For production purposes an alternative method of separating the acetal is, however, recommended. This consists in treating the reaction mixture with sodium bicarbonate to neutralize the acid and adding a large amount of sodium chloride. The volatile constituents of the mixture are then distilled off. The residue assumes a pasty consistency and on stirring breaks up into lumps which, after a short period of drying, can be crushed. The powder is washed free of sodium chloride first by decantation and then on a filter and, finally, vacuum dried at 98-100 degrees. Tests on the products obtained from mixtures containing different proportions of polyvinyl acetate to acetaldehyde showed that with a ratio of the latter to the former equal to 2, a degree of substitution of 83 per cent. was obtained, which corresponded to the 70-80-per-cent. substitution characteristic of the materials produced by the Shawinigan Chemicals, Ltd. However, the fluidity of the products as determined in a Raschig mould was too low and could not be improved sufficiently by raising the proportion of acetaldehyde. Changing the drying temperature was also without effect.

Further experiments showed that the fluidity of the polyvinal acetal increased with a decrease in the viscosity of the original polyvinyl acetate used, but, nevertheless, it could not be increased sufficiently by this means. A reduction of the concentration of the acid to 1 per cent. was also ineffective, but it indicated, however, that the fluidity of the acetal was related to the degree of hydrolysis of the polyvinal acetate. To reduce hydrolysis, the acetalation reaction as described above was carried out in the presence of ethyl acetate added in the molar ratio to the polyvinyl acetate of 1 : 1, an equimolecular proportion of alcohol and twice the molecular proportion of paraldehyde being also added. The reaction was continued for 10 hours. The polyvinyl acetal obtained had a melting point of 135 degrees C., a viscosity of 11.6 c/n, a fluidity (Raschig mould) of 188 mm., a molar absorption of 0.73 per cent., a Brinell hardness of 21.6, and a Shore hardness of 70. These properties are regarded as satisfactory for practical purposes.

Development of Alkyd Resins

Some interesting investigations on Alkyd resins have recently been published by P. I. Dmitriev. (*Zhurnal Prikladnoy Khimii*, XII, 1939, No. 10, pp. 1536-1547; XII, 1939, No. 12, pp. 1848-1855, and XII, 1939, No. 12, pp. 1856-1862). The first of these articles describes a study of the production of glycitrate resin by the esterification of glycerine with citric acid under various conditions. In all the experiments, 94 per cent. glycerine was directly esterified with crystalline citric acid. The first of these experiments was carried out at atmospheric pressure at 179-180 degrees C. Subsequent experiments were carried out at reduced pressure (20 mm.) at the same temperature. The reaction led to the formation of a viscous or solid product soluble in water to an extent depending on the molecular proportions of the two constituents. Heating was continued for varying periods of time and the progress of the reaction was observed by determining the changes in the acid number and other means. Continued heating

brought about the formation of a sponge-like material which was insoluble in the cold, but swelled up on heating in alcohol, benzol, acetone, water, etc.

Again, in other experiments the esterification was conducted in the presence of methyl, ethyl, propyl and amyl alcohols, acetone, turpentine, benzol, and carbon tetrachloride, at atmospheric pressure. The solubility in water of the resins obtained in the presence of alcohols decreased with increasing molecular weight of the alcohol. The acid number of the resin decreased as the proportion of glycerine to citric acid was increased. The molecular weight of the resin obtained when using three mols of glycerine to 1 mol of citric acid was 419-409, and with 5 mols of glycerine to 1 mol of citric acid the molecular weight was 218.

For a more detailed study of the composition of the products obtained, they were separated into fractions by fractional precipitation from an alcoholic solution by the addition of benzol. Six fractions were obtained in this way, the molecular weights, acid and ester members of which were determined. The results obtained for the fractions of glycitrate resin indicate that the product obtained under the above conditions consists mainly of the α triglyceride of citric acid (first fraction) and of a small amount of α, β, α^1 monglyceride of citric acid (sixth fraction), while the intermediate fractions consist of mixtures of the two. It must be mentioned that preliminary tests had shown that the resin did not contain any free glycerine or citric acid.

Modifications of Alkyd Resins

The data obtained in the above and some additional experiments on the esterification of glycerine with citric acid were used to determine the order of the reactions taking place and to calculate the rate of reaction constants. The esterification of glycerine with citric acid is shown to be a second order reaction. In the first phase of the reaction the whole of the citric acid is converted to the α monoglyceride of citric acid, the second phase leading to the formation of the diglyceride ester, and only the third phase yielding the α triglyceride. The soluble glycitrate resin gives films from aqueous or alcoholic solution, which when formed at 150-180 degrees are insoluble in water, the resistance to water increasing with an increase in the proportion of glycerine up to 3 mols to 1 mol of citric acid.

The use of the resin for varnishes for glues and as a substitute for gum arabic in water colours is suggested. In the second of the three articles referred to above the author describes some work on the production of alkyd glyphthaladipic resins, i.e., resins obtained by the simultaneous esterification of glycerine with phthalic anhydride and adipic acids.

Preliminary experiments were carried out to study the rate of esterification and the end products of glycerine when esterified with the two acids individually. In both cases it was found that an increase in the amount of the acid used caused the reactions to proceed more rapidly, i.e., products with a low acid number were obtained more rapidly, or the resin more rapidly reached an insoluble and infusible state. The glyptal resins were formed more rapidly than the glyadipic resins, which is explained by the greater reactivity of the phthalic anhydride. The resins obtained on heating glycerine with phthalic acid, adipic acid, and with both together in different proportions were soluble in alcohol and acetone, and solutions in the latter were used to obtain films the hardness of which was measured. It was found that the film hardness increased the longer the time of film formation and the higher the acids content of the resins, the phthalic anhydride giving rise to harder resins than the adipic acid. In addition, the hardness was influenced by the method of producing the resins. Resins formed by direct esterification of the glycerine with the acids give softer films than those formed by the step-wise esterification of the hydroxyl groups of glycerine.

Almost neutral resins were obtained only with an excess of glycerine over the acids, and the greater the excess of hydroxyl groups the fuller the esterification, while the resins themselves almost never passed into the insoluble and infusible state.

In the final article P. I. Dmitriev discusses the problems connected with modified alkyd resins and provides some experimental data. The modified alkyd resins contain the fatty acids of drying oils and are capable of drying, whereas the free fatty acids by themselves generally do not give films. In addition, the introduction of fatty acids into alkyd resins renders the latter soluble in the cheaper solvents. The direct introduction of the fatty acid or oil into the alkyd resin is, however, difficult and requires the melting of the resin and the use of a catalyst such as calcium glycerate, acid calcium phthalate, etc.

In his experiments, however, the author investigated the method of introducing the fatty acids by the alcoholysis, with glycerine, of the oil during the condensation of the glycerine with the acid to form the alkyd resin. The glycerine was condensed with oxalic, sussinic, adipic, sebacic, phthalic and citric acids in varying proportions in order to study the effect of the acid radical on the resin and subsequent film formation of the modified resins, the reaction being carried out in the presence of non-drying castor oil and oxidized drying linseed oil, semi-drying cottonseed oil and raw and polymerized linseed oil, the object being to investigate the effect of the structure and the presence of hydroxyl groups in the oil.

Physical Tests of Films

Films of the modified resins obtained from turpentine solutions were tested for hardness and permeability to water. It is concluded that for oxidized linseed oil and castor oil the time of alcoholysis is directly proportional to the content of glycerine in the reacting mixture, whereas the alcoholysis of cottonseed oil and raw and polymerized linseed oil requires the use of a catalyst. The former two oils lead to homogeneous modified resins, while the others do not. Modified alkyd resins, containing castor oil and oxidized linseed oil, do not combine with alkyd resins, but mix in all proportions with the above oils, and are readily soluble in benzol and turpentine.

Alkyd resins modified with oxidized linseed oil yield films at 20 and 140 degrees C., which are softer than those formed by the oil itself. The hardness of films decreases with an increase in the amount of glycerine and acid contained in the modified resins, modification with oxidized linseed oil giving harder films than modification with castor oil, the same being true for the use of adipic, as compared with oxalic acid.

A study of the composition of glyptal resins has also been described by A. I. Kogan (*Zhurnal Prikladnoy Khimii*, Vol. XIII, 1940, No. 3, pp. 436-442). The work was carried out on resins obtained by condensing phthalic anhydride and glycerine and ethylene glycol, respectively, in different proportions by heating for varying periods of time. These resins were separated into

various fractions by precipitating their solutions in acetone with water. The fractions with a higher molecular weight precipitated out first. The resins derived from glycerine had a higher viscosity than those derived from glycol. The first fractions, too, had a higher viscosity. The glycerine-base resins had the maximum viscosity at equimolecular proportions of the two constituents and a minimum viscosity in the presence of excess of glycerine; while the glycol-base resins had a maximum hardness in the presence of an excess of phthalic anhydride and a minimum hardness when the glycol was in excess.

Differences in properties between fractions are more marked in the case of resins obtained by prolonged heating.

Use of Timber Resources

In view of the wide availability of timber in the U.S.S.R. the use of wood and wood derivatives in the plastics industry is receiving a good deal of attention.

Thus L. V. Gordon, L. N. Kozlovskaya and L. L. Korshun have started an investigation into the use of phenolic products obtained from wood in the production of plastics, their first report *(Lesokhimicheskaya Promyshlennost,* 1939, No. 9, pp. 15-24), dealing with the use of phenols from the tar obtained by dry distillation of deciduous tree wood. Earlier work had indicated that the phenols had first to be separated from the neutral oils which accompany them in the pitch. This was done by repeated saponification with caustic soda, the neutral oils being removed by blowing with steam, or by extraction with ether or benzol. The neutral oil contents of different samples of phenols used were found to be 0, 1, 1.8-2.5 and 4.7-8.5 per cent.

Fractions of 190-220 degrees, 190-230 degrees and 190-250 degrees were condensed with formaldehyde. The proportions used were 105 parts of 40 per cent. formaldehyde to 100 parts of the phenols. Heating was done on a water-bath, and in the experiments the amount of caustic soda used as the catalyst and the time of heating were varied. The best results were obtained by using phenols boiling up to 220 degrees and having a neutral oil content not exceeding 2-2.5 per cent. To obtain phenols with such a content of neutral oils, extraction is not necessary, blowing through of steam being sufficient. The best samples of resin obtained were light yellow in colour and were free from any objectionable smell. On substituting pure crystalline phenol for 30 per cent. of the wood phenols a resin was obtained with a rate of polymerization of 30-40 seconds at 160 degrees C. The best samples of resin were converted into powders, with which moulding experiments were carried out. Resin obtained from wood phenols alone and from mixtures of wood phenols and crystalline phenol (in the ratio of 7:3) were mixed by the varnish method with partially hydrolized wood flour (resin content of powder 30 per cent.); the powder was rolled for 2-2½ minutes at 70-90 degrees and moulded for 10 minutes at 110 degrees C., under a pressure of 300-400 kg/cm². Specimen mouldings obtained from the resin produced with and without the addition of pure phenol had impact strengths of 5.2 and 4.4 kg/cm². respectively, cross-breaking strengths of 360 and 390 kg/cm², and a water absorption (increase in weight) of 0.6 and 0.3 per cent. in 24 hours and 1.3 and 0.7 per cent. in three days respectively. Satisfactory results were also obtained in experiments on the use of wood phenols in the production of phenol-formaldehyde—dicyandiamide resins and mouldings and of a laminated wood material. The authors outline a proposed technological scheme for the separation and purification of wood phenols. The plant suggested is characterized by the simplicity of its constituent units.

Lignin Plastics

Another investigation on resins derived from wood products is that by Ya. M. Lukomskiy and S. I. Kucherenko *(Lesokhimicheskaya Promyshlennost,* 1939, No. 9, pp. 52-56), which deals with the production of mouldings from a material consisting of a phenol-lignin resin and wood shavings. The shavings can be either of the type used for packaging or those obtained in wood working. The resin is used in the form of an alcoholic solution or an aqueous suspension. The shavings, in the form of strips 20-30 mm. long, are dried to a residual moisture content of 8-10 per cent. and are then impregnated during 30-60 minutes with an alcoholic solution of the resin. Hexamethylene tetramine is added to the resin solutions, which also contain dibutylphthalate in the case of alcoholic solutions, or glycerine in the case of aqueous solutions as plasticizers. Suitable compositions are given. The impregnated shavings are taken from the solution, the excess of which is pressed off, air-dried and finally dried at about 60 degrees C. The amount of the resin binder in the dried product may vary from 28.6 to 51 per cent. Before moulding, the material is tableted. The actual moulding can be done either in closed moulds or between plates. Moulding pressures vary between 100 and 250 kg/cm², and the temperature is 150-160 degrees C. Moulding is continued for 1-1.5 minutes for every 1 mm. thickness of the moulding. The mouldings are cooled under pressure down to 80 degrees C.

Mechanical Properties of Lignin Plastics

The moulded material was found to have an impact strength of 7.8-10.1 kg/cm/cm² at 20 degrees C. and 8.2-12.3 kg/cm/cm² at 55 degrees, an ultimate cross-breaking strength of 830-915 kg/cm², a Brinell hardness of 38.1-43 kg/cm², a heat resistance (by Martens method) of 126-186 degrees, and a water absorption (increase in weight in 24 hours' immersion) of 0.93-3.1 per cent. The best mechanical properties were obtained with material containing pine-tree packaging shavings, while material containing fir-tree packaging shavings had the best heat resistance, and material made up with birch-tree wood-working shavings had the least water absorption and the best electrical properties. It is interesting to note that, contrary to the behaviour of other phenolic resins, the mechanical properties of the materials obtained by the above methods increased at low temperatures. Thus the cross-breaking impact strength at −55 degrees C. was 20 per cent. higher than that at +20 degrees C. These new materials should find applications mainly for panelling and other architectural uses.

" Rockite " Moulding Materials

We have received from F. A. Hughes and Co., Ltd., a handy booklet in loose-leaf form containing much valuable information regarding the physical and mechanical properties of their plastic materials. Included are not only the properties and uses of five different Rockite moulding powder groups (there are some 26 grades) but also valuable information on Cellomold, their thermoplastic moulding, and on the extrusion of Rockite resins.

Inquiries and Answers

(In Which is Included General Correspondence)

IMPORTANT NOTICE: If inquirers wish to receive replies by post, a stamped and addressed envelope must be included in their letter. It is understood that the submission of a problem to the Editor permits its publication in this journal

Metallic Powders and Plastics

We have read your leading article in the October number of *Plastics* with particular interest and strongly endorse your final remark that further co-operation is eminently desirable between manufacturers of plastics on the one hand and powder metallurgists on the other.

We have followed the many references in *Plastics* to the utilization of metals in the plastic industry, and have been impressed by the largely empirical nature of most of the attempts to use metals, whether in powder form or not.

We are unlikely to minimize the difficulties that lie in the path of a wider use of powder metals as adjuncts to plastic materials, but we are far from considering the problems involved insoluble. In some respects they are paralleled by the difficulties already met with in incorporating pigments in plastic masses; here, too, we feel that up to the present a policy of taking the line of least resistance has been predominantly followed, and so various difficulties have not been solved but only evaded.

If powdered metals are to fill the niches in the plastic industries which they are uniquely fitted for, it will be by the closest co-operation between the two interested parties. It cannot be too strongly emphasized that powder metals can never be thought of as neutral filler materials. On the other hand there are so many ways of modifying the behaviour and reactivity of metal powders that there are few physical properties and conditions that the powder metallurgist cannot provide for. What is called for to-day is a close liaison between the plastic technician and the powder metallurgist permitting first of a frank discussion of requirements, a survey of ways and means, a correlated series of investigations, and finally, the production of materials comprising metal and plastic which will cover the widest range of specifications envisaged as possible or desirable. Only in this way can the essential body of experience and knowledge be built up which will ensure metals playing the fullest part in the plastic industry.

POWDER METALLURGY (1940), LTD.
London, E.C.3.

Printing Type

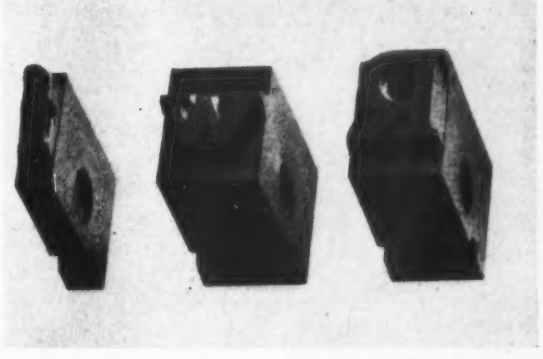
Can you tell me if printing type has yet been made of plastics, so that advantage may be taken of the great difference in weight between plastics and the usual heavy metals? J.J.C.
Leicester.

[EDITOR'S NOTE.—The only information that has come to our notice was an article in Kunstoffe last year by M. E. Laeis, of which the following is an abstract. Although the polymer used is not disclosed, it is probably of the polystyrene type.

The great dimensional accuracy which is attainable with injection mouldings has led to this process being investigated for the production of synthetic-resin printing-type, as a substitute for the corresponding process using metallic alloys. The following is a description of developments since the beginning of 1936, carried out by the Deutsche Verlag, Berlin, the Dynamit A.-G., Troisdorf, and Messrs. Eckert and Ziegler, Köln-Braunsfeld.

In the first instance an ordinary mould, as used in the well-known monotype machines, was used, with appropriate modifications to meet the much higher pressure (1,200-1,400 kg./sq. cm.) necessary for the manipulation of thermo-plastic resin as compared with molten alloys.

Whilst the casting of a lead-alloy character takes only half a second, the moulding of a similar article in thermo-plastic resin requires 12-15 seconds. In order to render the new process competitive as regards rapidity, multiple moulds were therefore adopted in which 20 characters, identical or different, could be produced in one operation. The durability of the synthetic resin characters



was then tested by using these side by side with metal characters in haphazard fashion for the printing of a number of large editions, information being obtained at the same time regarding the behaviour of the plastic towards printing ink and cleaning operations. From this it was found that certain polymerides form the best materials for the moulded characters. The used type can, within limits, be reworked, and to that extent the material shows less deterioration than occurs with type alloys. To meet the special accuracy requirements of type moulding, special multiple moulds have been developed, for use in Messrs. Eckert and Ziegler's normal automatic injection-moulding machine, in which the small fins left on the moulded characters are removed cleanly and automatically when the mould is opened; the characters emerge separately from the mould.

The plastic characters are suitable primarily for hand composing. Their durability has been well established, and they have the following advantages:—

(1) A weight only about one-eighth of that of metal type (Sp. gr. of the synthetic resin, 1.05);

(2) Greater accuracy than metals, giving better quality reproductions;

(3) Immunity from corrosion;

(4) No hygienic objections; and

(5) Better wearing qualities, so that a larger number of impressions can be taken from the same set-up than is possible with metal type.

The problem of adapting the new material to the linotype principle may be solved eventually by the development of quicker-setting thermoplastics. The lightness of the material offer great possibilities in the direction of lightening the construction of printing machinery, particularly the moving parts thereof.]

Treating Fish Bait

I would be very grateful if you could assist me in giving your advice on the following little problem.

I have been attempting to apply a coating of clear celluloid to small fish which I use in salmon fishing, the advantage being that they are thereby rendered durable and in addition take on a glossy surface which is an additional advantage.

The following method has been used but success has been limited, because, as each coating has been applied, it has had the effect of contracting and distorting the shape of the fish.

I have made a solution of clear sheet celluloid with equal parts of amyl acetate and acetone to a consistency of thick cream. Successive coats are applied by dipping until the desired thickness of celluloid is obtained. At least six coatings is usually required

Can you suggest what you consider would be a more suitable material than celluloid to use for this purpose and where it can be obtained. J. R. COURTNEY.

[EDITOR'S NOTE.—There seems little doubt that the reader is using too crude a solution for the job. The modern cellulose lacquers (e.g., those for spraying motorcars) are carefully compounded so that the solvents do not volatilize too rapidly and so produce wrinkling. Most manufacturers produce transparent lacquers for dipping purposes.]

We have received the following additional letter from Mr. Courtney in answer to one of ours asking for further details as to the prior treatment of the fish. We feared that without such action the small fish might expand rapidly through decomposition and grow as large as the salmon he was hoping to catch. He obviously knows all about that.

"It is very kind of you to write me fully on my little problem, and also for your helpful suggestions.

"The fish I mentioned are real fish. To be exact, they are very small sprats, measuring anything from three to four inches.

"They are first of all preserved in a solution of formalin, and before coating with celluloid, they are taken out, dried and degreased. They last indefinitely in normal use.

"The advantages are obvious. From the salmon's point of view they are real fish, and from the fisherman's point of view they last indefinitely and do not require to be frequently changed as is necessary when fishing with the sprat in its soft natural state.

"I might say that this idea is not originally mine. Some baits prepared in this way have recently come on the market, and have proved very successful. In fact my own preparation with the celluloid solution have also proved successful, but there is much room for improvement."

[EDITOR'S NOTE.—We can now sincerely hope that Mr. Courtney's catches will increase in direct proportion to the improvement in his cellulose lacquer, and may his salmon never be under 30-pounders!]

Oven Doors

In reading through your November publication of *Plastics*, Volume IV, No. 42, under the heading "Inquiries and Answers," we notice that Turley and Williams, Birmingham, have asked about transparent plastics and materials suitable for oven doors, and you advise glass similar to Pyrex.

We have asked our Birmingham manager to contact Messrs. Turley and Williams, and bring to their notice that we manufacture "Armourplate" glass, which has been used extensively for cooker doors. "Armourplate" is an entirely different material from Pyrex, inasmuch that it is 5/6 times stronger than ordinary glass of the same thickness when submitted to severe impact, and in addition it will withstand changes of temperature to 300 degrees C. even when sprayed with cold water.

We are enclosing one of our "Armourplate" booklets herewith. PILKINGTON BROS., LTD.

St. Helens, Lancs.

[EDITOR'S NOTE.—We are glad to help other industries where it is clear that plastics are not suitable, although, as we have said before, it is "all my eye and Betty Martin," to think, as one expert does, that ". . . transparent plastics cannot be considered as competitors of glass . . . . they are the willing allies of glass to be used with, etc., or to help it out of those spheres where it functions with difficulty or not at all." Scientifically this sounds well enough and is indeed true. Economically it means little, and is even an amusing euphemism. To us, as scientists, the information that "Armourplate" is so strong and heat resisting is a welcome and noteworthy achievement. There are many plastics protagonists, however, who will spend the rest of their manufacturing or trading lives in trying to oust glass whether the latter is better or not.]

Building Boards

I note from your August, 1939, issue of *Plastics* a report on a new German process of manufacturing plywood resin boards for building construction. I am curious to know if any further information on this subject has come to hand, or whether you can guide me in tracking down this information.

In the same issue mention is made of the cheapest plastic material in the world made from "Lignin." I would appreciate similar information on this subject to enable me to obtain full details and sample.

SAM BUNTON, A.R.I.A.S., M.Inst.R.A.

[EDITOR'S NOTE.—With regard to the first item we regret we have no further information on the German process. As for resin-treated plywood boards in general, the inquirer will get information from Bakelite, Ltd., Brackley Lodge, Brackley, Northamptonshire, and from British Industrial Plastics, Ltd., 1, Argyll Street, London.]

Lignin plastics have been the subject of much recent research, a most important building sheet being Benalite, a product of Masonite Corp., Laurel, Miss., U.S.A., from which concern samples can be obtained. We gave the same data regarding this material in our July issue, p. 151.]

Plastic Discs

We would very much appreciate your assistance in finding the name and address of a manufacturer who supplies thin circular discs in a plastic base material. The discs, we believe, can be used for shimming milling cutters and the like, and are procurable in various colours, each colour representing a specific thickness.

W. A. ROBERTSON AND CO., LTD.

Bedford.